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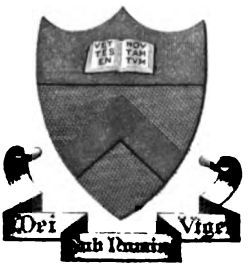

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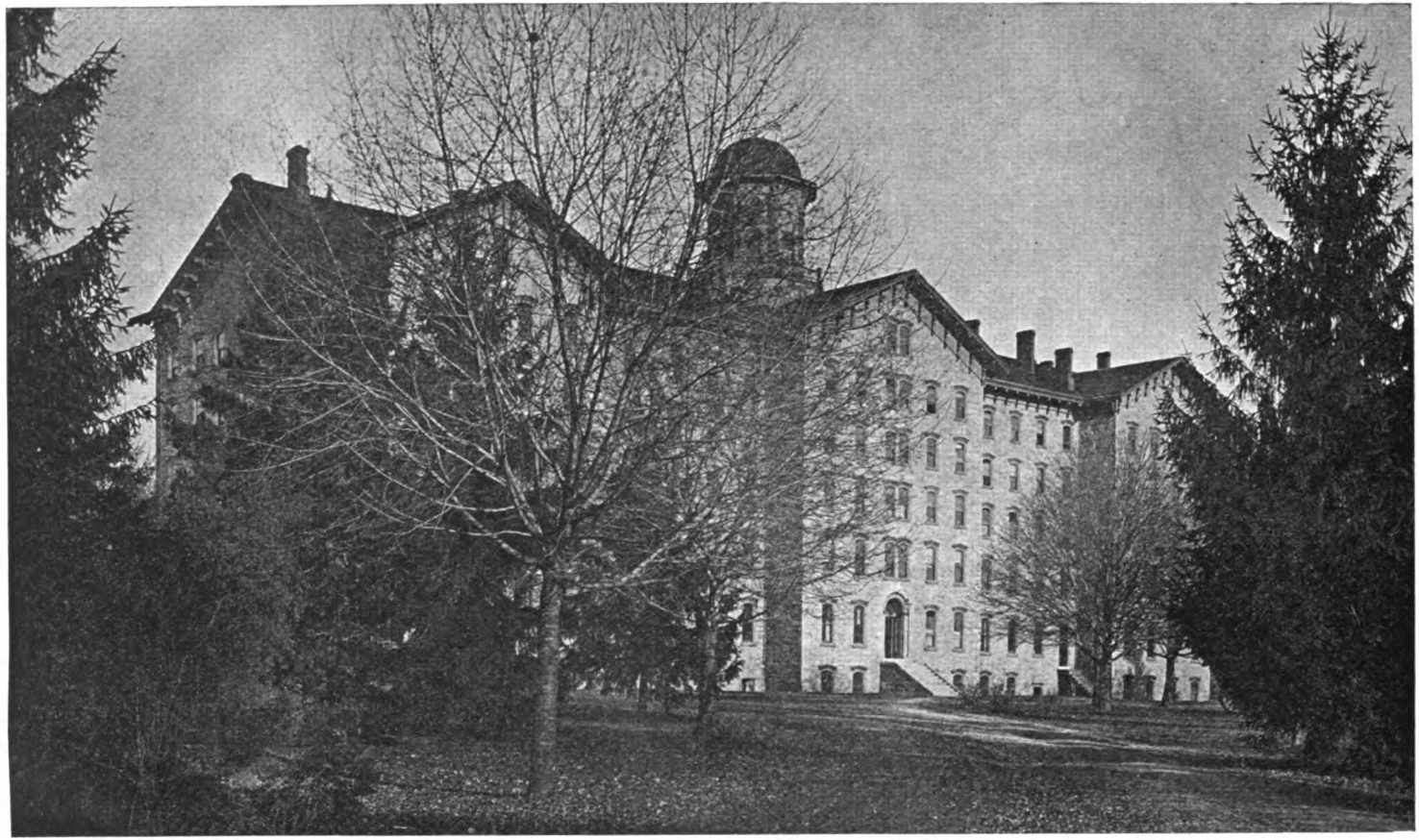

THE PENNSYLVANIA STATE COLLEGE. (MAIN BUILDING.)

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REPORT

OF THE

PENNSYLVANIA STATE COLLEGE,

FOR THE YEAR 1888.

HARRISBURG:
EDWIN K. MEYERS, STATE PRINTER.
1889.

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REPORT

OF THE

PENNSYLVANIA STATE COLLEGE,

FOR THE YEAR 1888.

HARRISBURG, PA., *January 25, 1889.*

To the Senate and House of Representatives of the Commonwealth of Pennsylvania:

I have the honor herewith to transmit the treasurer's report of the receipts and expenditures of the Pennsylvania State College, for the year 1888, as required by law; and, in connection therewith, the reports of the president of the college, of professors in charge of some of the departments of instruction, and of the building committee. I venture to call attention to the report of the president, and to those of the mechanical and agricultural departments as containing matter of great interest to the people of the Commonwealth.

FRANCIS JORDAN,
President of the Board of Trustees.

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PRESIDENT'S REPORT.

To the Board of Trustees of The Pennsylvania State College:

GENTLEMEN: I have the honor herewith to submit my report for the year 1888, accompanied with those of professors in the several departments of the College.

The general condition of the College has remained substantially as reported one year ago; continuing to show the same gratifying indications of growth in popular favor, thoroughness of work and increase in the number of students.

The only important change in the faculty has been the resignation of the Chair of Chemistry by Professor William H. Herrick, and the appointment in his place of Professor G. G. Pond, recently an instructor in Amherst College.

Professor Pond brings to his work a high reputation for scholarship and success in teaching and administration; this reputation he has fully sustained in his present position, and there is every promise that the Department of Chemistry, if sustained by the Board in the same liberal spirit as heretofore, will continue to rank as one of the strongest and most important in the College.

Besides the change in the Chair of Chemistry, changes of instructors have occurred as follows: Miss Julia E. Gorsline, Instructor of Music, resigned her position in June last, and was succeeded by Miss Josephine Hoogs who, however, retained the place but a single term. Mr. F. W. Spanutius, a graduate of the Sheffield Scientific School, was appointed Assistant in the Chemical Laboratory at the beginning of the year, in place of Mr. Davies. Mr. Caldwell was appointed Assistant in Agriculture in order to leave Dr. Frear more time to devote to the work of the Experiment Station. Mr. George C. McKee, while pursuing special post-graduate studies in the Department of Electrotechnics, has also given some instruction in the same department of the College, and in the Preparatory Department.

The work of the Faculty in general during the past year has been characterized by the same earnestness, efficiency and devotion to the interests of the College, as in former years; and the growth of the Institution is very largely to be attributed to their faithful service. The only regret I have to express in this connection is that services so important are not more adequately compensated; and I earnestly desire that the time may come when the salaries of the professors and instructors may be made somewhat more nearly commensurate with the value of the work they are doing.

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The number of students during the past year has been larger than ever before in the history of the College; and, with scarcely an exception, they have been pursuing regular and continuous courses. Nothing in the recent history of the College has been more marked and gratifying, and a surer guarantee of stable growth in the future, than the general tendency on the part of students to avoid irregular and partial courses, and to take instead full and complete courses, leading to a degree. The success of many of the graduates who have recently gone from the College may, to some extent, account for this tendency; but it is also attributable in some degree, to the fact that our students enter with much better preparation than formerly, and that there is in them a growing spirit of earnestness and manliness which cannot be too highly commended. With the exception of rare and transient departures from good order, the general tone of life and conduct among them has been highly satisfactory.

The failure of the contractors—partly from unforeseen causes, and partly from want of sufficient energy—to complete promptly the repairs in the main College building, occasioned very serious inconvenience and injury during the entire fall session. It is only within the last few days that we have been able to make use of the recitation rooms in the central wing of the building, and the chapel is still unfinished. The changes made, however, will prove to be a great relief in many directions, by giving us more and better recitation rooms, and light and ample hallways. When, in addition to these changes in the main building, the new structures now under way are completed, as they will shortly be, so as to relieve to some extent our present crowded condition, the ordinary work of the College can be far more easily carried on. It is manifest, however, that even these additions to our room are insufficient to accommodate the increasing number of students, accompanied as it is by an increasing variety in our departments of instruction.

Several additional buildings are greatly needed. The first, and perhaps the most imperative need, is that of a new building for the Preparatory Department. A few years ago, when the number of students was small in both College and Preparatory Departments, there was no occasion for providing separate quarters for Preparatory students outside the main building. Even then the change would have been a great relief in the matter of regulation and daily movement, since it is necessary to prescribe study hours and other restraints for youth who have not yet formed habits of study and conduct, which are altogether inapplicable to students in college; and the difficulty of maintaining two different sets of regulations under the same roof and in connecting sections of the same building, is far greater than might at first sight appear to those who have not had actual experience of it. But considerations of convenience merely no longer exist. The building is crowded; every dormitory room in the Preparatory

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and College Departments is occupied; more students than ever before have taken rooms with families in the village, and even then it was necessary for the Executive Committee, at the opening of the year, to hire a large building outside. Meanwhile, the recitation rooms for the Preparatory Department, which have been kept in the main building, have become entirely inadequate, both in number and in size, and relief is a matter of urgent and imperative necessity. The most obvious way of finding that relief is by removing the entire Preparatory Department into a building or buildings for its own exclusive use. It would thus be possible to maintain such a system of supervision as the age of the students in that department requires; to adjust their work without any reference to conflicts with College work; to give them more attractive quarters, and in every way greatly to increase efficiency and smoothness of work. This relief would also give additional dormitory rooms for College students; would enable us to provide recitation rooms for two or three departments that are now obliged to obtain quarters wherever they can, from time to time, and would furnish us some greatly needed rooms for public purposes, such as museum, reading room, reception room, etc. If, besides this, a new building could be secured for the Ladies' Department outside, the change would not only give us all the rooms needed for College students for four or five years to come, but would be of the greatest possible advantage to the Ladies' Department. In fact, if that Department is to be maintained as a branch of the College work, I see no way of doing it satisfactorily except by giving it ample and convenient quarters in a building constructed for its exclusive use.

In this connection should be mentioned the establishment for ladies of a department practically new in the Institution. Ever since the College was opened to them, ladies have been regularly admitted to all classes in all courses, on the same terms and with the same requirements as young men. They have fully maintained their average of standing in the competition; and the number now in the college classes pursuing the regular four years' course, is larger than at any previous time in our history. Until within a few years a majority of them have contented themselves with the facilities offered in the Preparatory Department, and after completing the course there, have returned to their homes or sought employment as teachers or otherwise. It will be a most useful provision for all such—whether in the Preparatory or College classes, to establish a department of industrial art and design and one of Domestic Economy. The Department of Domestic Economy, which has been experimented upon in many institutions and in connection with many public school systems in the country, until its methods, its aims and its results are defined with substantial clearness, would prove an invaluable means of fitting young ladies for the performance of the ordinary duties of domestic life, not as a drudgery, but as an attractive exercise in the application of clear and intelligent

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knowledge of the sciences upon which such economy is founded. The department would not aim to make housekeepers, but would aim to teach botany, chemistry and physiology and domestic management, by means of the exercises of the class room carried on as a practicum in these sciences. Attention is particularly called to this subject in the report of the Lady Principal, in the recommendations of which I fully concur. The Department of Industrial Art and Design would be open to students of both sexes. For the students in the technical courses it would furnish suggestive and stimulating exercises in the direction of the special employment or profession for which they are fitting themselves, while for young ladies it would be not merely an attractive course of training, but an opening to new and desirable ways of obtaining a livelihood or of satisfying their own artistic sense.

Besides these important needs, four more residences for professors are required.

It is impossible any longer to furnish living quarters for families in the college building. The two now residing there are occupying rooms which are needed for other purposes, and we are liable at any time to have changes in the teaching force, either by way of additions or substitutions, for which residences will be indispensable, but which we have at present no means of providing.

Still another need which must be provided for before next fall is a large addition to our heating and lighting arrangements. The appropriations for buildings made by the last Legislature were not sufficient to cover the cost of heating apparatus. For two of them temporary provision has been made in the expectation that the Legislature would at this session provide the necessary funds; but for two others—the armory and the chemical laboratory—no provision whatever has yet been made. After giving the subject such attention as I have been able to, my judgment is that the only proper way of providing for this present and future need, is the establishment of a central plant, with buildings and boilers sufficient to furnish heating for all the public purposes of the Institution for the next few years, and constructed on such a plan that future enlargement will be easy without great additional expenditure. If, in connection with this, the power for lighting and for mechanical purposes can be joined, it would be an important saving in cost of maintenance, as well as in the concentration of all the handling of coal and ashes at one point. Such a concentration, also by removing fire from the various buildings, will greatly reduce the cost of insurance on them. Less necessary than the things already mentioned, but still of great importance, is the removal of the barn from its present location in the midst of the College buildings, and the re-arrangement of the interior of the main building, both of which will be required at no distant day.

Looking at the situation in the broad view of a wise and economical public policy, it is not too much, in my judgment, to ask the Legisla-

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ture to provide at once for all the wants specified. It seems like a considerable expenditure of money at one time; but it will be wiser and cheaper in the end to proceed upon a well-considered and comprehensive plan, than to undertake a piecemeal policy which is unsatisfactory at present, and without guarantee or promise for the future.

I am persuaded also that the Legislature should be asked to make provision for removing the mortgage indebtedness now existing, and for a regular annual maintenance of the leading departments of the College. A few years ago, when recitation rooms, dormitories, residences for professors, museums, society halls, and in fact the whole provision for the life and work of the College could be included in a single building, it was possible, though, of course, with a good deal of inconvenience, to provide a moderate appropriation each year from the stated income of the College for the maintenance of the most important departments, and for keeping up—though in a meagre way—the most necessary repairs. But this is no longer possible. The necessary increase in the number of buildings involves, of necessity, a corresponding increase in the janitor force; the cost of heating and lighting; the maintenance of walks and roadways; repair, maintenance and enlargement of the buildings themselves, and also requires, as is obvious on a moment's reflection, a greatly enlarged equipment in order that the few things which appeared respectable in their small and restricted quarters, may not seem even more inadequate than they are when placed in larger rooms. But far more important than that is the fact that the work of each department is growing so rapidly, our students are feeling so keenly their competition with the great body of students in similar institutions in other States, and our work is becoming subjected so constantly to comparison with that in other institutions, that it is a matter of pressing and overwhelming necessity that each department shall be provided with such appliances as are sufficient to economize the time of professors, and to place in the hands of the student whatever apparatus is necessary to enable him to do the best work of its kind. Whatever advantages can be procured for the most favored youth in the best institutions, should be freely provided for the students of The Pennsylvania State College. We ought to ask for nothing more, we ought to be satisfied with nothing less; and I believe the time has come when the best public opinion of the State, reflected in the general sentiment of all branches of the State Government, would condemn us as wanting in a proper appreciation of our duty to the public, if we did not make these wants known to the State Legislature, and insist that every consideration of public policy demands that they be promptly and fully met.

To summarize these various statements with others of the same kind which might with propriety be treated in detail, I present the following list of what, in my judgment, is required, not merely to put the

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institution upon a broad footing of permanent prosperity, but to enable it to meet the demands which here and now, daily and hourly, are pressing upon it. I give also an estimate of the minimum amount of money required:

For repairing the main College building and rearranging the interior, thirty thousand dollars; for refurnishing it with suitable furniture and equipment, ten thousand dollars.

For erecting, fitting up, equipping and furnishing a building for the Preparatory Department, sixty thousand dollars.

For building, fitting up, equipping and furnishing a building for the Ladies' Department, forty-five thousand dollars.

For erecting, fitting up and equipping the necessary additional buildings, boilers and dynamos, and providing the necessary appliances for heating and lighting the several College buildings and for supplying power to the machinery required for the Mechanical Department, forty-five thousand dollars.

For erecting, furnishing and equipping a building for the Departments of Civil and Mechanical Engineering, fifty thousand dollars.

For re-building the barn and other outbuildings belonging to the College farm, twenty thousand dollars.

For erecting and equipping a suitable dairy house, feeding barn and implement shed, and repairing the present barn, for the use of the Agricultural Experiment Station, ten thousand dollars.

For grading the grounds and making and repairing the necessary walks and roadways upon the premises, twelve thousand dollars.

For erecting and fitting up four residences for professors, twenty thousand dollars.

For paying the mortgage indebtedness of the College, forty thousand dollars.

For the erection and equipment of a conservatory for the use of the Department of Botany and Horticulture, two thousand five hundred dollars.

For increasing the water supply, erecting improved fire escapes, and otherwise perfecting protection against fire, ten thousand dollars.

There are also needed for defraying the ordinary and necessary expenses of the College the following amounts:

For necessary repairs, improvements and insurance, five thousand dollars.

For the maintenance and increase of the College library, reading room and museum, five thousand dollars.

For the maintenance of green houses and propagating houses in connection with the Botanical and Horticultural Departments, two thousand dollars.

For the maintenance of the necessary walks and roadways, and care of the grounds, one thousand five hundred dollars.

For the maintenance of the Mechanical Department, including fuel,

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increase of machinery, apparatus and equipment, services of machinist and engineer, five thousand dollars.

For apparatus and equipment for the Department of Civil Engineering, one thousand dollars.

For apparatus and equipment for the Department of Physics and Electrotechnics, three thousand dollars.

For apparatus and equipment for the Department of Chemistry, one thousand dollars.

For the maintenance and equipment of the Department of Industrial Art and Design, to be conducted with special reference to the industries of this State, three thousand dollars.

For the purchase and repair of necessary desks, chairs and other furniture, one thousand dollars.

Quite as urgent as the need for more room is the need of some additions to the teaching force. I have already indicated that the salaries paid are insufficient. The College has always been successful in securing the services of a body of men of learning and ability in their several departments, many of whom have done work not inferior to any similar work elsewhere. It has such men in its departments today; but, besides being underpaid, several of them are overworked, either by the multiplication of subjects or by the lack of means to employ suitable and necessary assistants. Not to dwell upon this point, but merely to enumerate, we need at once a full professor to take charge of a portion of the Department of Natural History; an instructor in the English language, Rhetoric and Elocution, whose time shall be given exclusively to training students in the art of written and oral expression from the time they enter the Institution until they graduate; an instructor in Drawing—free-hand and mechanical—whose work should furnish also the nucleus of the Department of Industrial Art and Design; an Instructor in the Department of Physics and Electrotechnics, whose full time should be employed there; another in the Department of Chemistry; another in the Department of Mathematics, and another in the Department of Mechanics and Mechanical Engineering. I am perfectly aware, of course, that the resources at the command of the trustees render any such increase of the teaching force now impossible; but it is the very least that will man our departments properly, and what we must have unless the Institution is to stand still at its present stage of growth.

In closing, I desire to express my thanks to the Board of Trustees for a greatly needed respite from duty in the early part of the year, and for their continued cordial support, as well as to the Faculty for their cheerful performance of additional work during my absence and their continued fidelity and zeal. It seems proper, also, that I should mention the constant and unremitting labors of the Building Committee in supervising the erection and completion of our new buildings during the past year.

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REPORTS OF DEPARTMENTS.

1. AGRICULTURAL EXPERIMENT STATION.

STATE COLLEGE, PENN'A,
January 30, 1889.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: I have the honor to present to you the following report of the work of the Agricultural Experiment Station of the Pennsylvania State College, for the year 1888.

As noted in my report for 1887, I was not able to assume personal charge of the work of the Station until the close of that year. While the experimental work proper to a Station has been actively carried on, and considerably extended in scope since that date, the greater portion of my time has necessarily been devoted to questions of organization and equipment. The large increase in the funds available for experimental work in agriculture, and specially the terms of the so-called "Hatch Act," donating to the College $15,000 annually from the Treasury of the United States, made necessary a more complete organization of this department of the College, and a separation of it in certain particulars from the other departments corresponding to the difference in the character of its work.

Accounts.—In order to meet these new conditions, so far as they affected the finances of the Station, the Board voted, June 30th, 1887, "That the work in agricultural experiment and investigation carried on at and in connection with the Central Experimental Farm be hereafter conducted under the title of "The State College Experiment Station, and that the books of account be kept accordingly." In pursuance of this resolution, a separate set of books was opened for the accounts of the Experiment Station, and early in the present year the keeping of these books was, by vote of the Executive Committee, transferred to the Director of the Station. From that time until June 30th, the books were kept upon substantially the system previously adopted.

In view of the fact, however, that we have to account both to the United States Treasury for expenditures under the "Hatch Act," and to the State of Pennsylvania for expenditure of the appropriation made by the State, it was felt that our system of book-keeping should be modified so that the books should show upon their face the expen-

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ditures from each of these funds, as well as of the funds coming from sales of farm produce. A system of accounts was therefore adopted on July 1, 1888, with the approval of the Executive Committee, by which the books will show each of these three classes of expenditures by itself, and will also show separately the cost of labor expended under any given account.

Owing to delay in procuring the new set of account books, and to pressure of other work, it has not been found possible yet to put the new system in operation, and the accounts up to date have been kept upon the old system, but with such notes as will permit the transfer of the accounts to the new books, and it is expected that this transfer will be made very soon.

Another change, rendered necessary by the requirements of the United States Treasury Department, was the closing of the books on June 30 to correspond with the close of the United States fiscal year; consequently the books have not been balanced at the close of the calendar year. I would respectfully request that the Board take into consideration the question of when the books of the Experiment Station should be closed. If possible under the provision of the State law, I recommend that the time of closing the books be June 30.

Officers of the Station.—At the beginning of the year the officers of the station were as follows:

H. P. Armsby, Ph. D., ... Director.
William Frear, Ph. D., . . Vice Director and Chemist.
William A. Buckhout, M. S., ... Botanist.
George C. Butz, M. S., ... Horticulturist.
William C. Patterson, . . . Superintendent of Farm.
H. J. Patterson, B. S., ... Assistant Chemist.

During the year the following additions have been made:

George L. Holter, B. S., } . . . . . Assistant Chemists.
W. S. Sweetser, B. S., }
William H. Caldwell, B. S., . . . Assistant Agriculturist.
Miss Julia C. Gray, ... Clerk and Stenographer.
George Olley, ... Gardener.

Mr. Harry J. Patterson, who for the preceding two and a half years has had immediate charge of the chemical work of the Station, resigned on July 1, to accept the position of Chemist of the Maryland Experiment station, his place with us being taken by Mr. Holter.

New building.—One of the first needs of the Station under the new conditions was adequate office and laboratory accommodations, the old quarters of the Station in the College building being too small for its needs, and the room being urgently needed by the College for other purposes. It was, therefore, voted by the Trustees, January 24, 1888, to proceed with the erection of a building expressly for the accommodation of the Experiment Station, at a cost not to exceed $15,000.

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After consultation with the other officers of the Station, and an inspection of the new building of the Massachusetts State Experiment Station, a plan for such a building was submitted to the Building Committee, and adopted by them without material change. A brief description of the building with cuts showing the floor plans and two elevations was furnished by request to the September number of "*Agricultural Science*," and is reproduced with this report. The building is now approaching completion. In the meantime the Station has occupied temporary quarters in the College building at the cost of much inconvenience to the Station and still greater inconvenience to the College.

Experimental work.—The system of field experiments which had been carried on for several years upon the Central Experimental Farm has been continued without material change during the past year. Full meteorological observations have also been continued during the year. In connection with this work, arrangements were made early in the season by which the Station receives the daily weather indications sent out by the United States Signal Service, and displays them in the customary manner, by means of flags, from the tower of the College building.

In considering what additional work should be undertaken by the Station. I have been impressed with the importance of doing whatever is practicable towards developing the live stock industries of the State, not only on account of the direct profits which might thus be gained by farmers, but even more on account of the indirect benefits arising from the conservation and increase of the fertility of the soil consequent upon stock raising and feeding. Considerable work has, therefore, been done upon feeding problems and more is projected and partly in process of execution. For details of this work, see the reports of experiments on subsequent pages.

Publications.—As required by the "Hatch Act," the station has published four bulletins during the past year, viz: No. 2, published in January, on "Field Experiments with Phosphates;" No. 3, published in April, on "Composition and Digestibility of Corn Stover;" No. 4, published in July, on "Seed Germinations;" No. 5, published in October, on "The Digestibility of Soiling Rye." A small pamphlet was also printed in August, entitled "List of Experiments in Progress." This was not sent out as a bulletin, but was distributed in connection with an exhibit of the work of the Station made at the Williams' Grove Grange Picnic, and at the State Fair in Philadelphia.

The mailing list of the Station has been somewhat increased during the year, and now contains over 11,000 names.

Improvements.—It appears to me that one of the most advantageous lines of experiment which the Station could take up would be experiments in relation to dairying, particularly butter production. The dairy interest is already prominent in certain portions of the State, and it is very desirable on many accounts that its growth should

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be encouraged. Before the Station can prosecute this line of work, however, certain additional equipment will be necessary, which the present means of the station do not permit it to procure.

First. We need more cows. The number kept at present is just about sufficient to supply milk for our regular customers, and we should hardly be justified in refusing to supply them under present conditions.

Second. Additional stock will require additional barn room.

Third. There is needed a dairy house, properly equipped for both ordinary dairying and experimental work.

Fourth. A small addition to the barn where the more accurate experiments may be carried on free from the inconvenience and liabilities to error inevitable in work carried on in a large general barn.

I need make no comment upon the first of these needs. As regards the second, abundant room may be obtained by remodelling the basement of the present barn and using the whole space, including that now employed, as a tool shed. We should also gain in this way a direct connection between the feeding room and the silo. This change, however, involves the erection of a new implement shed and carriage house to shelter the implements, etc., now kept partly in a division of the basement and partly in various other places. I may add that in my judgment such an additional building is very much needed independently of its relation to other projected improvements.

I submit herewith outline plans for the above alterations and improvements. I have, unfortunately, not been able to obtain an accurate estimate of cost, but an approximate estimate would be $7,200, including equipment.

I would respectfully urge upon the board the desirability of securing from the present Legislature, if possible, an appropriation for these improvements. The amount required is not very large, and I believe the purpose of the appropriation would commend itself very generally to the farmers of the State and to the Legislature.

Salaries.—In conclusion, I desire to ask the attention of the Board to certain considerations bearing upon the division of salaries between the College and the Station. I assume, as the basis of all discussion of this matter, what I believe to be the sentiment of the Board, that no part of the Station funds should be diverted from experimental work to payment for teaching in the College, but that the salaries of officers who have both Station and College duties should be divided between the two, substantially in proportion to the amount of time and energy devoted to each. When the salaries were fixed at the last annual meeting of the board, however, no experience was available to determine what would be a just division, and, as I understand it, the arrangement then made was a tentative one, subject to change in the light of further experience. On this understanding of the case, I desire to present the following statement of the amount of time

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actually devoted to College and Station work, respectively, by the officers of the Station. It must be premised, however, and will readily be seen, that no mathematically accurate statement can be made. To obtain as fair an estimate as possible I have requested each officer of the Station to prepare a statement of the amount of time which he has given to College work during the past year, asking him, if in doubt, to make the estimate too low rather than too high, and to include only time actually spent in class duties and in *direct* preparation for them. The only exception to this was in the case of the Horticulturist, who has included in his statement the time actually devoted to the care of green-house, orchard, vineyard and campus.

In computing the percentage of time given to College duties, I have assumed that an average of eight hours per day for six days in the week is as much work of this sort as any ordinary man should be expected to perform, or practically will perform.

The value of room-rent, etc., when furnished by the College, has been computed at the rates charged to students, and added to the cash salary.

Division of Salaries between College and Station.

Dr. Frear:

Average time required for class-room work and preparation, 14–17 hours per week, equal to 29–35 per cent. of 48 hours.

Salary:

Room rent,	Sleeping room,	$53 50	
	Study,	53 50	
		$107 00	
Cash,		1,500 00	
		$1,607 00	of which the
College pays,		107 00	or 6.66 per cent.

Mr. Butz:

Average time for classes and practicums, 28½ hours per week, or 59 per cent. of 48 hours.

Salary:

Room rent,	$107 00	
Cash,	1,500 00	
	$1,607 00	of which the
College pays,	607 00	or 38 per cent.

Mr. Caldwell:

Average time for classes, 17 hours per week, or 35 per cent. of 48 hours. Salary, $800, of which the College pays $200, or 25 per cent.

For convenience of reference, I add the following compact summary of the above statement:

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	Per cent. of time given to College.	Per cent. of salary paid by College.
Dr. Frear,	29–35	7
Mr. Butz,	59	38
Mr. Caldwell,	35	25
Mr. Buckhout,	Nearly all.	50

Very respectfully,

H. P. ARMSBY,
Director.

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2. AGRICULTURAL CHEMISTRY.

STATE COLLEGE, PA., *January 14, 1889.*

To the President of The Pennsylvania State College:

SIR: I have the honor to submit the following report of my department for 1888. Since my last report the work of the department has been put upon a much more satisfactory basis than heretofore. Up to the early part of the year the instruction in all the purely technical branches pertaining to Agriculture, except horticulture and entomology, devolved upon myself, and I was also required to give a large share of my time to experimentation. The pressure of the work has now been very considerably diminished by an arrangement under which the Assistant Agriculturist of the Experiment Station is employed for part of his time in instruction. The assignment of the technical branches of the department for the past year has been as follows:

To Professor Buckhout, comparative physiology and entomology; to Mr. Butz, horticulture; to Mr. Caldwell, elements of scientific agriculture, crops, anatomy and breeding, veterinary science, dairy farming and sheep husbandry; and to myself, agricultural chemistry—elementary and advanced—fertilizers, agricultural engineering, cattle-feeding, farm economy and history of agriculture, as well as the supervision of the work of several students taking special studies.

Agricultural instruction of the grade maintained here is made difficult by the absence of modern agricultural text-books adapted to the needs of advanced students. This lack renders it needful to supplement or replace the text-book by lectures upon the special topics. For the preparation of lectures that shall compactly embody the essentials of a subject, from both the scientific and the practical standpoints, and cull the most important results of the widely-scattered, modern experiments, much time and labor are required. The advantage arising, under such conditions, from the subdivision of the work of instruction is readily apparent.

The endeavor in this department has been to secure such a presentation of the several branches, accompanied by corresponding practice, that the student will, at the end of his course, have at his command a knowledge of the principles underlying farm practice, and an acquaintance with the various methods adapted to farm production under different conditions, such that he will be enabled to apply the means at his command so as to secure the greatest and most profitable product. He should be able to select the system of farming best

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adapted to the climate, soil, markets, and prevailing practice of his locality; to select varieties of crops, and adapt methods of cultivation intelligently with reference to the peculiarities of his surrounding conditions; to improve varieties, test seed, and identify and properly treat the weedy, parasites and insect enemies that destroy his crops; to determine, by experiment, the fertilizer best fitted for his use, how it is most advantageously applied, and, by analysis, whether it comes up to guarantee; to harvest his crops and put them into the best market condition; to select the best stock for breeding and for milk, meat and wool production; to secure the best condition of farm animals for maintenance and production; to diagnose and treat the more common diseases, and to know when to call in the services of a skilled veterinarian; to use farm machinery, and, when necessary, to make the minor repairs; to lay out a system of drains, irrigation ditches, or a road, and to plan and supervise the construction of his farm buildings; to apply the results of others' experiments intelligently to his own conditions; or to enter as a specialist into some line of agricultural manufacture or research. Every student upon completing either Agricultural Course, will have been instructed with reference to the principles governing the practice in each of these agricultural operations, and will have spent regularly a considerable portion of time in the practice of those operations which seem best suited to his individual needs.

In connection with this practicum work the increased facilities for practice in horticultural operations in consequence of the erection of the green-houses, and in the study of horticultural and agricultural varieties, and of agricultural experiments in field and stable, due to the extension of our experimental work by the establishment of the Station, are worthy of special mention.

As in previous years, a large share of my time and energy has been devoted to the work of the Experiment Station.

In closing, I desire to acknowledge the zealous coöperation of Mr. Caldwell, who has relieved me of the immediate charge of a large amount of class-room work.

Very respectfully,

WM. FREAR,
Professor of Agricultural Chemistry.

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3. BOTANY.

STATE COLLEGE, PA.,
January 10, 1889.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: I have the honor to make the following brief report of the Department of Natural History for the year 1888. There have been but slight changes in the schedule of studies or in the general conduct of the department. In the work in the Preparatory classes and in botany and horticulture, I have been well assisted by Mr. Butz, who makes a report direct to you.

The average of attainments of students has been good, and in some cases very good indeed.

Those who have been conditioned were either notoriously negligent, or so unfortunate as to have fallen behind because of absence or sickness.

We have made some advance in our facilities for laboratory work and in putting them abreast of the times, but we have still much to do.

The year was signalized by the removal of my department into a new and commodious building which had been erected for it. Unfortunately it was not entirely completed at the beginning of the fall session, and it was not until the middle of November that the noise and annoyance caused by having mechanics at work while recitations were going on finally ceased, and the heating apparatus was in working condition. We now have, however, very comfortable and convenient rooms, and when they are suitably furnished and supplied with water and light, application for which has been made, there will be but little to desire in the way of accommodations.

As to immediate needs they are, first, the working facilities referred to as having been applied for, and, second, a series of type specimens, casts and models, the cost of which would be several hundred dollars.

Respectfully submitted.

WM. A. BUCKHOUT,
Professor of Botany and Horticulture.

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4. CHEMISTRY.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: From my very brief acquaintance with the Chemical Department, I have very little to report as regards work done or results accomplished. I wish however to report to you the condition of the laboratory as I found it and to outline the needs of the Department and the methods of instruction by which I hope most efficiently to serve the College.

With the new laboratory so nearly completed, our present inadequate quarters need not be a subject for remark at this time, but the equipment of the same, never too complete, has now become quite too meager for our needs. By authority of the Executive Committee, I have ordered from Germany a good working supply of chemicals and apparatus. These goods will be here by the first of April next, and after that date, I think, there will be no further embarrassment to the progress of work in the Department on account of lack of material. It is a matter to be deplored that we have no gas for laboratory use, since it is the use of gas which has made possible the progress of the science during the last twenty-five years; but with the completion of the new building we trust that this difficulty will be removed.

Our chemical work commences with the sophomore year. We devote the fall term to a thorough drill in the chemical relations of the non-metals. Nothing more is attempted, for, this being the real foundation and everything else being superstructure, nothing but uncompromising thoroughness and perfect familiarity with the material at this point can be tolerated. Copious illustration is given, for the student must be brought to understand that he is coming in contact with realities and the mind must be appealed to through the eye; but the practicum during the first term I consider of minor importance, because the student must first see a variety of experiments before he can appreciate the importance of taking the material into his own hands. Some beginnings in manipulation may of course be made and from two to four hours of practicum per week may be profitably employed. But nothing must cause us to lose sight for a moment of the fact that the importance of our work for the first term consists in building a broad and solid foundation in the science; and hence no inferior work *can* be accepted here, for the teacher must recognize, even though the student may not, that nothing in subsequent labor can fully make up for any defects in a secure foundation.

With the second term a change may be made. No concessions are made to lack of thoroughness, but the student depends more upon his own work. A beginning has been made. The student has become

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acquainted with the nature of the work demanded of him. The practicum may come to the front and the student become, in a measure, an investigator. This term the metals are considered. Their properties and relations to previous material are given in lecture, and a large store of information should be brought to the attention of the student in this way, while the behavior of metallic compounds under all circumstances with re-agents is made a subject of continual practical study at the hands of the student himself. The chief stress is now laid upon the laboratory work. The teacher should never be absent, but should be always on the alert to see that no time is lost, no opportunity omitted; to aid in forming habits of accuracy and cleanliness. Constant drill too in the way of quizzing and examining upon points of importance, as they occur in the laboratory, must ever accompany the manipulations of the student, and he must be made to feel that while to make of him a good manipulator and technical student is not to be neglected as a subserving means, nor yet to be considered as unimportant in itself, still the real object lies far deeper than this and is not reached short of a severe discipline upon every faculty of the mind, such as very few branches of study can achieve.

The field of qualitative analysis is compassed in two terms and mastered in as minute detail as that time will allow. In the junior and senior years quantitative analysis, organic and theoretical chemistry are taken up in logical order, and such branches of applied chemistry as can be arranged for are inserted at proper places.

We respect the feeling entertained by many individuals, that the practical knowledge to be acquired in some specific department must be chiefly sought in order to secure a livelihood; but we cannot think it wise in any case, though it is a frequent practice, to hasten rapidly and superficially over the whole ground-work of science and consider this a sufficient preparation for the advanced work of research. And we shall at no point allow ourselves to lose sight of our main purpose, namely—to direct a steady, systematic and symmetrical advancement, and to aid the student in constructing an edifice which shall not be narrow and tower-like, ready to topple and fall, but one which may rather be compared to the pyramid, broad-based, well founded and solid, and calculated to endure. Only a complete mastery of the ground-work of an extensive study can form a true and enduring inspiration for its continual pursuit.

Nearly thirty students, mostly sophomores, completed successfully the last term's work and are commencing with much enthusiasm the work of the present session. The number in advanced classes is small for obvious reasons. It will be larger another year. Very gratifying to me is the readiness of the students to adopt suggestions as to laboratory decorum, and the willing coöperation of pupils with teacher toward the common good, indicating a degree of manliness, crude at

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times. but always spontaneous and sincere, not everywhere to be found among students.

I need not remind you of the needs of the Department. When the new laboratory is made as practically useful as it is architecturally beautiful; when it shall be provided with gas supply and fixtures, with convenient working desks, with water and steam and with an adequate equipment of permanent apparatus, we shall have a laboratory second to none in the country for appropriateness and convenience. And with these prospects, I see no reason why we should not expect, in the very near future, to have here as perfect and successful a chemical department as is to be found in any institution, and to offer to our students every opportunity that can be afforded in any institution in the land.

It is most earnestly to be desired that at no distant day the Department of Mineralogy shall be given the prominence which it deserves by separating it from the Department of Chemistry, and placing it in the hands of some competent instructor whose other duties shall be such that he can properly handle it. It is certainly due to the Chemical Department, in which the whole time of two men could be profitably employed, that the mineralogy be set aside at the earliest possible date. For the present year I am willing to give the lectures in crystallography, but would urge that my assistant be given most of the responsibility of the mineralogical practicum, and that he receive additional pay for such portion of his time as this work demands. And here I would heartily commend the excellent work of my assistant, Mr. F. W. Spanutius, of the last class of the Sheffield Scientific School, whose faithful and painstaking assistance has rendered possible a larger accomplishment of work this year than would otherwise have been practicable.

I was obliged to commence the work with an indebtedness of about two hundred dollars. Our accounts are now balanced with no indebtedness. I would recommend the same appropriation as was formerly customary, four hundred dollars, to meet the expense of the lecture courses, and such other expense as cannot properly be charged over to the students.

In closing, permit me to thank you, sir, for the encouragement and assistance always received in carrying out my plans in all their details for the advancement of the work of the Department.

Respectfully,

G. GILBERT POND,
Professor of Chemistry.

January 12, 1889.

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5. CIVIL ENGINEERING.

STATE COLLEGE, PA.,
January 15, 1889.

GEO. W. ATHERTON, LL. D., *President:*

SIR: I have the honor to submit herewith the annual report of the Department of Civil Engineering.

In order that the development of the work of the department may be more clearly shown, I have concluded to select one line of work, descriptive geometry, and give some points of detail with reference to it. I consider the subject an important one, because it gives a very valuable mental training, and is of great practical value to the engineer.

The student begins the subject with problems on right lines and planes; here, as elsewhere, the work is almost entirely at the drawing board, solving original problems. This gives familiarity with general principles, which are then applied in problems on the different classes of surfaces, spherical and map projection, perspective and shades and shadows.

In order to accomplish enough in each topic to make it of sufficient value to the student, it has been necessary to concentrate on a few general principles of wide scope, and then to give practical problems on the applications of them. To illustrate this I have selected, from the general subject, two topics: spherical and map projections and perspective.

SPHERICAL AND MAP PROJECTIONS.

Projections are called spherical when the surface of a sphere is projected on a single plane. The plane may be that of one of the great circles of the sphere, and is then called the primitive plane; also the circle, the primitive circle.

Spherical projections may be classified as follows, viz:

Spherical projections.
- (1) Scenographic. (Point of sight at some finite distance.) — Scenographic becomes stereographic when point of sight is at either pole of primitive circle.
- (2) Orthographic. (Point of sight at an infinite distance.)

Only class (1) will be considered, since it is the most important in map projection, and of this class stereographic will be first taken up as having results quite peculiar to itself, and also as being a good preparation for the projection of maps.

Definitions.—The axis of the earth is the diameter about which it is known to revolve; the axis of a circle is the line through its center and perpendicular to its plane; the polar distance of a point is its distance from either pole of the primitive circle; the polar distance

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of a circle is the distance of any point in its circumference from either of its poles; the north and south poles are where the earth's axis pierces the surface. Distances on the surface of a sphere are measured along a great circle.

The earth may be regarded as a sphere, and represented by projecting certain of its points and circles, great and small. These may be defined as follows, viz:

(*a*) Great circles: (1) Equator, perpendicular to the earth's axis. (2) Meridians, passing through the earth's axis.

(*b*) Small circles: Circles of latitude, parallel to the equator.

The celestial sphere is the background against which we see the stars projected. It may be considered as a sphere of infinite radius, the earth being at the center. By extending the planes of the terrestrial great circles, just defined, we would obtain celestial equator and meridians. By producing the axis of the earth until it intersects the celestial sphere, we would obtain the poles of the heavens. In addition, we have the following celestial circles proper:

(1.) Ecliptic, the sun's path; it is a great circle, whose plane makes an angle of $23\frac{1}{2}$ degrees with the equator and intersects it in the equinoctial points; the solstitial points are on the ecliptic, 90 degrees from the equinoctial points. The meridians passing through the equinoctial and solstitial points are called the equinoctial and solstitial colures.

(2.) If a plane be passed tangent to any point on the earth's surface, and the plane produced until it intersects the celestial sphere, this intersection is called the horizon of that place. The horizon passes through the east and west points; the axis of the horizon intersects the celestial sphere in the zenith and nadir. A vertical circle is one whose plane is perpendicular to that of the horizon; the one passing through the east and west points is called the prime vertical.

It is to be remarked that while the poles and equator both celestial and terrestrial, the equinoctial and solstitial points and the ecliptic are the same for all places on the earth's surface, *i. e.* fixed, the zenith, nadir and horizon are essentially relative, *i. e.* they depend upon position on the earth's surface.

Since the radius of the celestial sphere is infinite, we may suppose that the plane of the horizon passes through the center of the earth, and hence that it intersects the equator in the east and west points, and if the meridian of the place be assumed as the solstitial, the east and west points become the equinoctial points. From the foregoing definitions it will be seen that:

(1.) The equator passes through the equinoctial points, and the east and west points of any horizon.

(2.) The ecliptic, through the equinoctial and solstitial points.

(3.) Any meridian, through the zenith, nadir, north and south poles, and north and south points of the horizon. Its east and west points falling at the center of the meridian.

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PLATE I

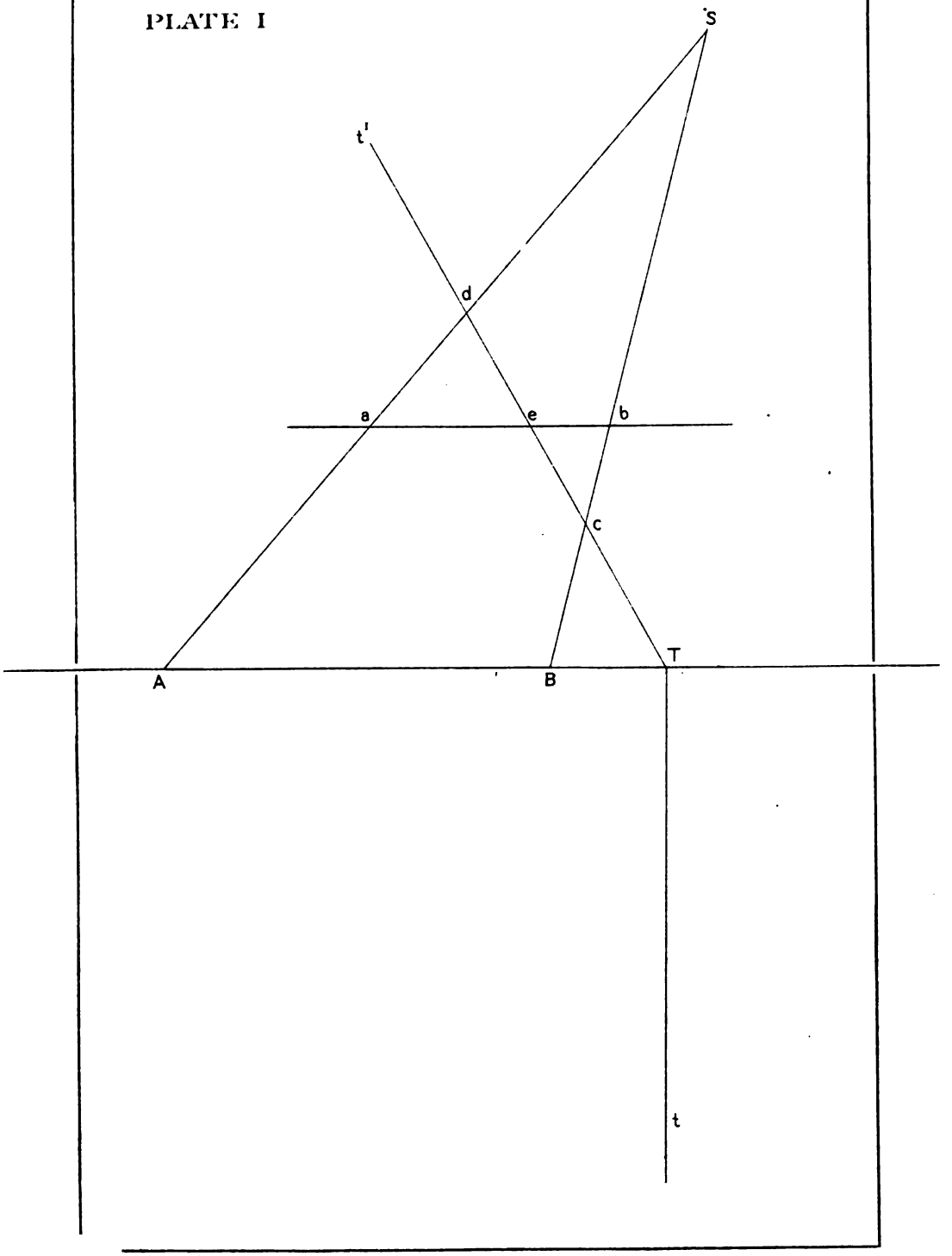

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PLATE I

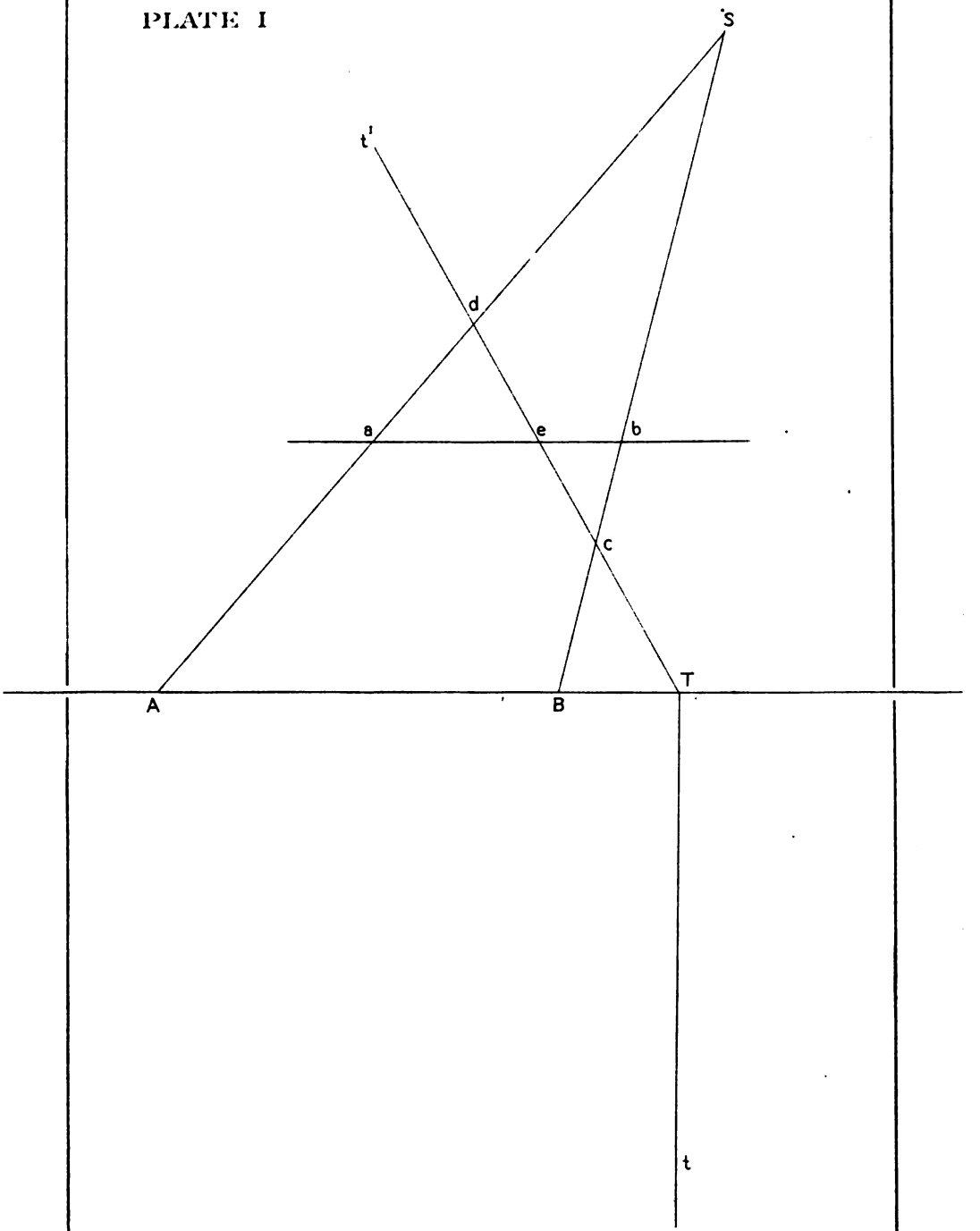

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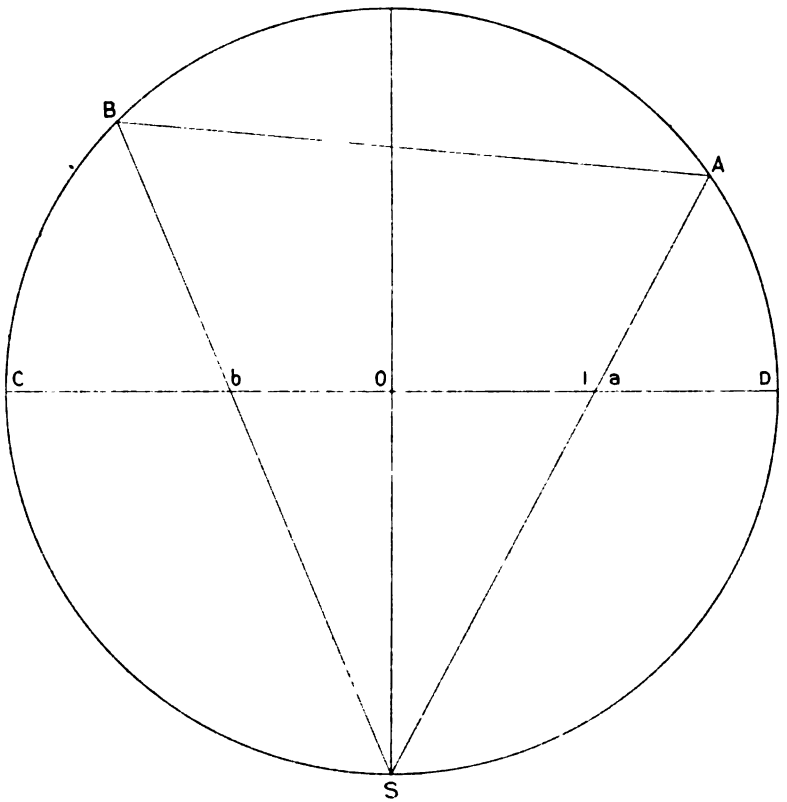
PLATE II



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(4.) Any horizon, through its east and west, and north and south points, the zenith and nadir falling at the center.

(5.) Prime vertical, through zenith, nadir, east and west points, with the north and south at the center.

If a plane be passed through the vertex of a circular cone, perpendicular to and through the center of its base it is called a principal plane, and the elements cut from it, the principal elements. In plate I, SA and SB are principal elements; *ab* the intersection of the cone by a plane parallel to the plane of the base. Pass a plane, tTt', perpendicular to the principal plane, so that S*ed* equals SAB. Then *ecb* and *ead* are similar triangles, and *cb : ed : : ec : ea*, or *eb. ea = ed. ec.* At *e* the circle *ab* and section *ed* have a common ordinate, D say. But *eb. ea* equals D^2, *ed. ec* equals D^2, and *ed* must also be a circle.

Hence the following statements, viz:

(1.) If a plane be passed through a circular cone so that the angle it makes with one element is equal to the angle the other element makes with the plane of the base, the section is called a sub-contrary section.

(2.) A sub-contrary section is a circle.

Let CD, Plate II, be the primitive circle, S, its pole, and therefore the point of sight. Pass a plane through the center of the sphere and S; its intersection with the former is SAB. Let AB be the orthographic projection of any circle of the sphere; *a* and *b* are the projections of A and B on the primitive plane, and *ab* is the projection of AB. ABS is measured by one-half of ADS, or one-half of AD plus 90 degrees, and SaC by one-half of SC plus AD, or one-half of AD plus 90 degrees. Therefore, SaC equals ABS. Thus *ab* is a sub contrary section, and hence a circle. We may, therefore, make the general statement that stereographic projection is peculiar in that all circles of the sphere project as circles. There are two exceptions to this statement, one of which is when the plane of the circle passes through the point of sight; the other will be noticed later. (See page 25, Case I.)

Theorem 1.—The stereographic projection of any point of the sphere is at a distance from the center of the primitive circle equal to one-half the tangent of its polar distance.

In plate 2, Oa is the required distance, and the truth of the theorem is readily deduced.

If a plane be passed through the axes of the primitive and any given circle of the sphere, its intersection with the plane of the primitive is called the line of measures of the given circle. It follows from this definition that it passes through the center of the primitive circle, and is perpendicular to the intersection of the given with the primitive.

Theorem 2.—The angle between two circles which intersect is the same as the angle between the projections of their tangents at the point of intersection.

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Let P be any point on the sphere (Plate 3), S the point of sight, CD the primitive plane. *p* is the projection of P; draw PT and PM tangent to the circles Pa and Pb; let P and M be the points in which the tangents pierce a plane tangent to the sphere at S, *p* and *m* corresponding points in the primitive plane. ST and SM will be tangent to Pa and Pb at S. Draw *pt* and *pm*. SMT and PMT are equal triangles by construction; therefore, the angle MPT equals the angle MST; but MST equals *mpt*; hence *mpt* equals MPT. Q. E. D.

Corallary.—Since the projections of the tangents are tangent to the projections of the circles, it follows that the angles between the projections of the circles is the same as that between the circles themselves.

Corallary.—The angle between the radii of the projections of two intersecting circles is equal to the angle between the projections of the tangents, and to the angle between the circles themselves.

Since the axis of a circle is at right angles to the plane of its circle, the angle between the axes of intersecting circles is the same as the angle between the circles themselves, and since the former is measured by the distance between their poles, it follows that the angle between two circles is equal to the angular distance between their poles.

Theorem 3.—If a small circle be perpendicular to the primitive, the projection of its center will be on its line of measures at a distance from the center of the primitive equal to the secant of its polar distance.

Let AB (Fig. 1, Plate IV) be the primitive circle, AB the intersection with it of the small circle. At A and B draw tangents; they will both pass through the center of the projection of AB, and determine, by their intersection, its position. Draw OS; it is perpendicular to A B, and, therefore the line of measures of AB. From the triangle SAO it is seen that SO is the secant of the polar distance, the radius being unity.

Theorem 4.—The center of the projection of a great circle will be on its line of measures, and at a distance from the center of the primitive circle equal to the tangent of its polar distance.

Let ABC (Fig. 2, Plate IV) be the primitive circle, and AB the intersection with it of any great circle of the sphere. At A and B draw lines making angles with AB equal to the angles between the circles. These lines intersect at O, the center of projection of AB; draw OS; it is evidently perpendicular to AB, and, therefore, is its line of measures; also, OS is the tangent of the angle between the given and primitive circles.

Theorem 5.—If the inclination of a given circle of the sphere to the primitive be called I, and its polar distance d, then the extremities of its diameter are at distances from the center of the primitive circle equal to tan. $\frac{1}{2}$ (I–d), and tan. $\frac{1}{2}$ (I+d).

Let CD (Plate II) be the primitive circle, S the point of sight, AB any circle of the sphere; *ab* will be its projection on the primitive

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PLATE III

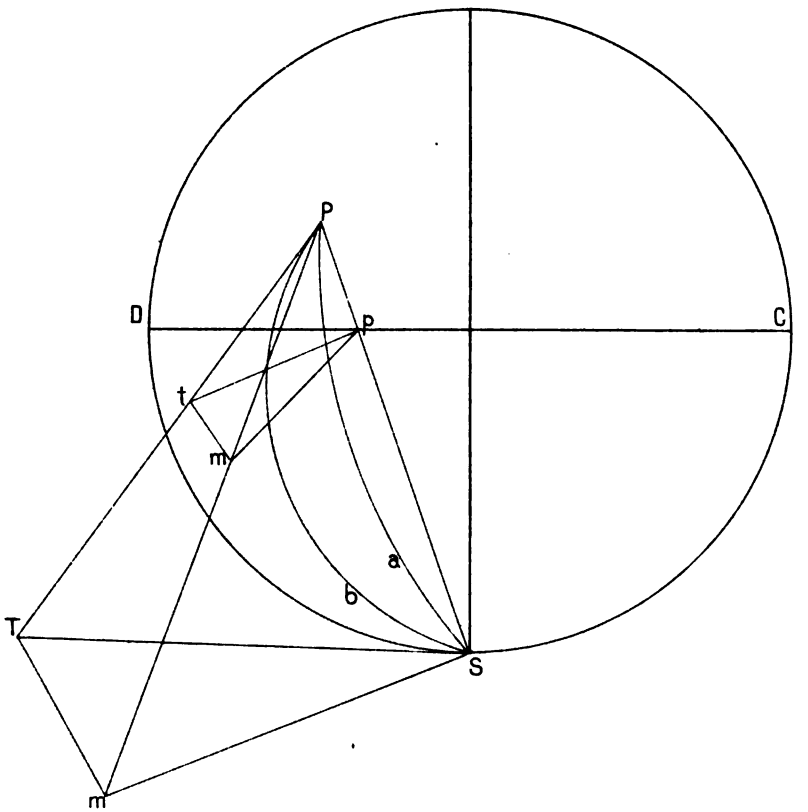

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PLATE IV

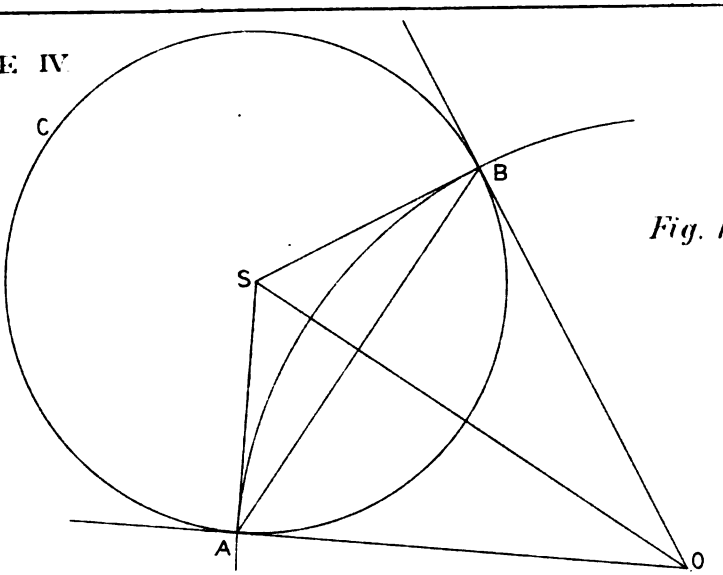

Fig. 1.

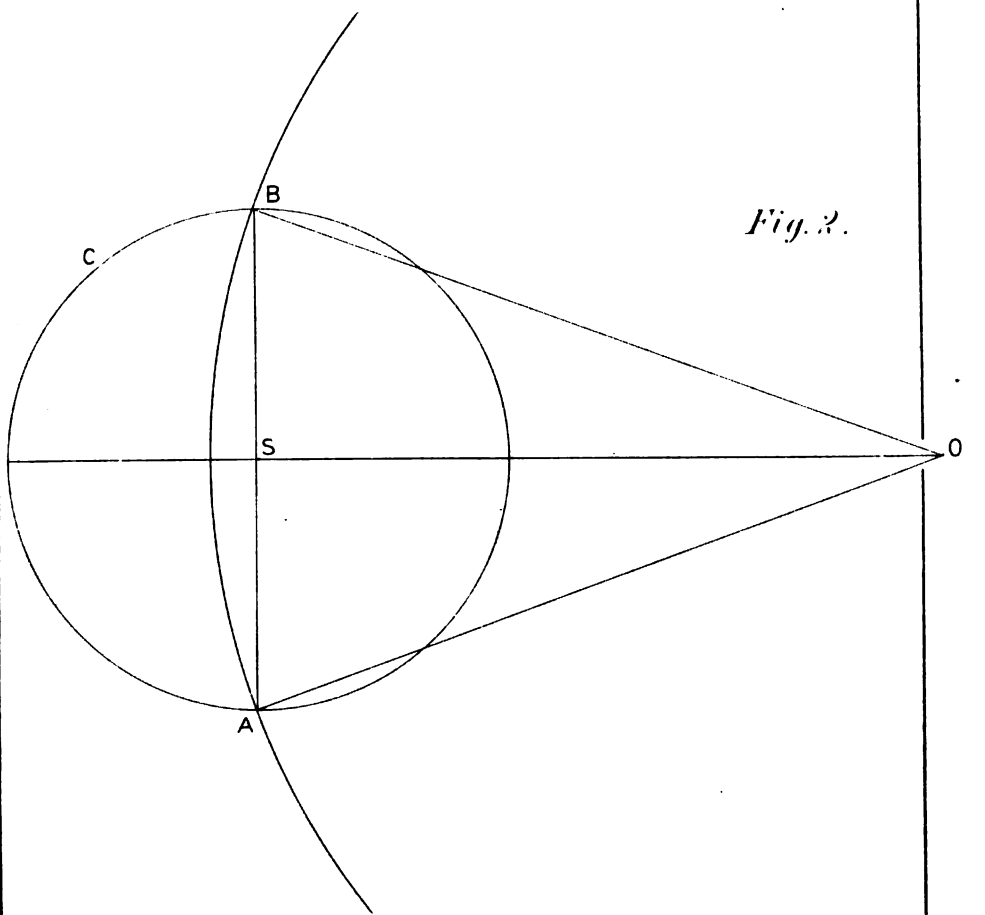

Fig. 2.

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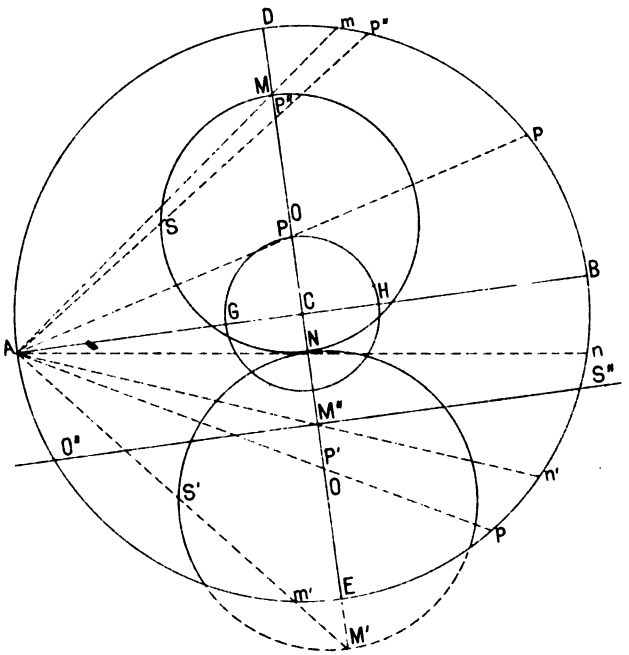
PLATE V



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plane, and it will be easy to deduce the above values for the distances Oa and Ob.

Theorem 6.—If a right line be tangent to a circle of the sphere, its projection will be tangent to the projection of the circle.

(The demonstration is left to the student as an exercise.)

Constructions.

Principal diameters: The diameter drawn through any point, and the one at right angles to it, may be called the principal diameters.

The plane of the primitive circle is considered to be a vertical plane, and the horizontal and vertical diameters are usually taken as the principal diameters.

1. To find the locus of all points having the same polar distance.

Let C (Fig. 1) be the center of primitive circle. AB and DE be the principal diameters; lay off the arc Bp equal to the polar distance. Draw Ap intersecting DC in P. With C as a center and CP as a radius describe a circle PGH. This is required locus.

2. To project a circle given the pole and polar distance:

Three cases arise, the construction for each depending upon theorum 5.

Case 1.

When the pole falls within the primitive circle:

Let P (Plate V) be the pole. Draw the diameter DE through P, also AB at right angles to DE. Draw AP, and produce it to intersect the primitive circle at p. Lay off pm and pn equal to the polar distance of the circle. Draw Am and An, intersecting DE in M and N. MN will be the diameter of the required projection. Bisect it at O, and describe the circle MSN. It is readily seen that Bm equals $Bp + pm$ (inclination + polar distance), and that Bn equals $pn - Bp$ (equals inclination — polar distance).

Should the polar distance of the circle be greater than the arc pD, the construction would be similar; the point M falling outside of the primitive circle. This is shown in lower half of Fig. 1; $NS'M'$ being the projection of such a circle.

Should the polar distance be the supplement of the inclination of the required circle, the point m would fall at A, and Am would become parallel to the diameter DE, and intersect it only at an infinite distance. Hence the radius becomes infinite, and the projection of the circle a straight line. To illustrate this, let P'' be the pole of a circle, whose polar distance equals $p''A$, lay off $p''n'$ equal to $p''A$; draw An', intersecting DE in M''. Then $M''S''$ drawn perpendicular to DE will be the required projection. Should the required circle be parallel to primitive circle, then its projection is concentric with it.

PC becomes zero. The radius will equal the polar distance of the the circle.

If the required circle be a great circle the construction becomes as

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follows (see Plate VI), viz: Let P be the pole; draw AP and produce to p, then pB equals the inclination of required circle. Now draw arc CG with A as a center, and AC as radius, and lay off CG equal to inclination, equal to pB, draw AG and produce to intersection with $P'E$ at O, and the primitive circle at B'. O will be the center of required projection. (See Theorem 4.) Since it is a great circle it must pass through A and B. Hence with O as center, and OA as a radius, draw ASB. It will be the required projection.

The following is another and shorter construction: Lay off pB' equal to pB; draw $B'A$, it will intersect $P'E$ at O, the center of required projection.

CASE 2.

When the pole of the required circle falls on the circumference of primitive circle:

Let P' be the pole of the required circle (see plate VI), and $P'E$ and AB the principal diameters. Lay off $P'n$ and $P'm$ equal to the polar distance; draw Am and An, thus determining M and N the extremities of the diameter of the projection as in Case 1. The following construction is shorter, however: Since the required circle is at right angles to the primitive circle, the lines drawn from the center of each to the point where they intersect must be at right angles to each other. (See Theorem 2, Corallary.) Hence from P' lay off $P'm$ equal to the pole distance of the circle. m is one of the points in which the circles intersect. The center of the required circle lies on the line EP', since EP' is its line of measures. The center will therefore be found by drawing a tangent to the primitive circle at m, and finding its intersection with EP' at O. Then with O as a center and a radius equal to Om, draw the circle Mmn.

CASE 3.

When the pole of the required circle falls outside the primitive circle:

Determine the extremities of the diameter as in Case 1, and describe the circle upon it. Fig. 1, Plate VII, illustrates the construction.

3. To find the locus of the center of all great circles that pass through a common point:

Let M be the given point (see Fig. 2, Plate VII). Draw AM and produce it to find m All great circles passing through M must also pass through a point 180° from M. To find this point lay off mn equal to 180°. Draw An and produce it until it intersects DE in N. N is the projection of a point 180° from M. MN is therefore a diameter common to all the great circles passing through M, and the centers of their projections will fall in the line GOH, drawn at right angles to MN through its middle point O.

A shorter construction is as follows, viz: Lay off Bm' equal to $2mD$; draw Am' and its intersection with DE will give the point O.

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PLATE VI

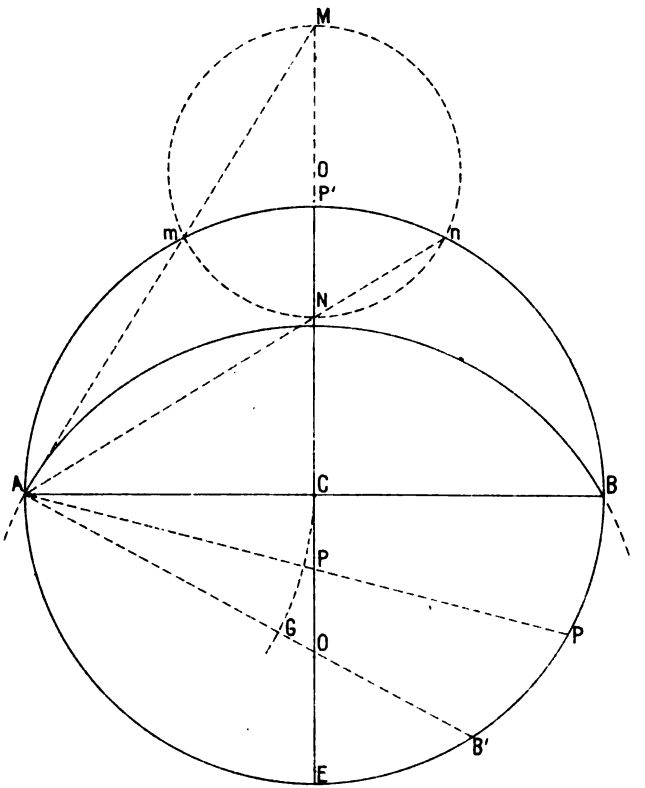

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PLATE VII

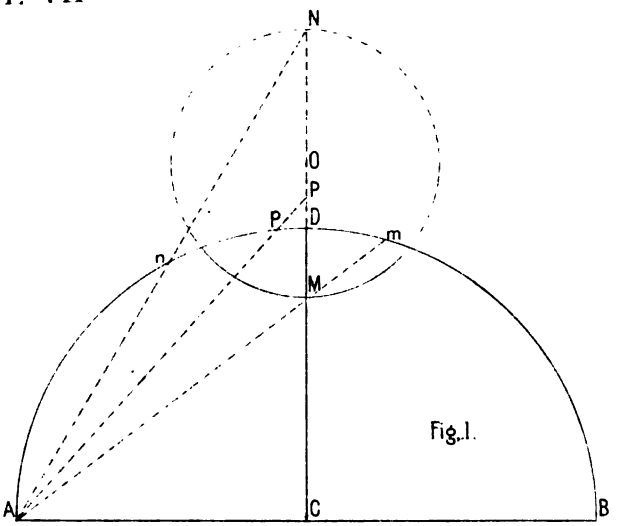

Fig. 1.

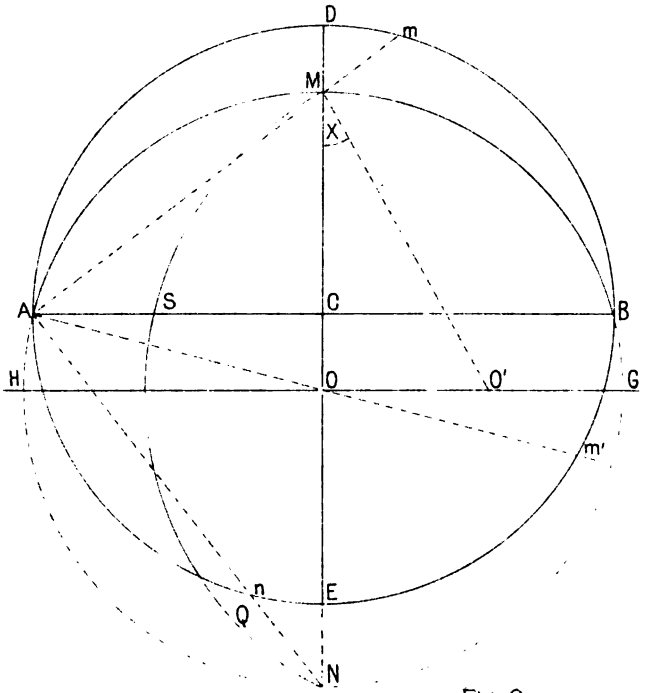

Fig. 2.

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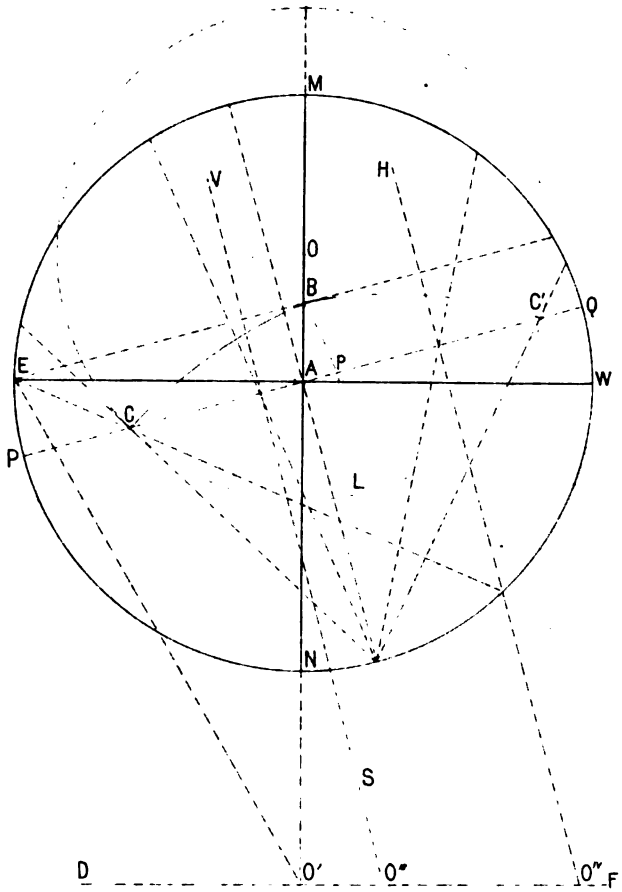
PLATE VIII



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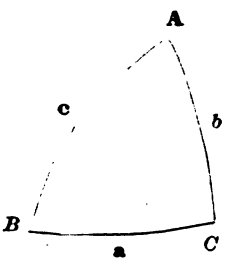
Bm' being two Dm, and Dm being the inclination of the circle through M at right angles to DE; so that CO is, by construction, equal to the tangent of the inclination. (See Theorem 4.) Then through O draw GOH as before. With O as a center and OM as a radius, draw the circle AMB at right angles to DE. To find the center of the circle that makes any angle X with DE, draw a line MO', making CMO' equal to the angle X; the intersection of this line with the locus HG at O' gives the center of required circle; then with O' as a center, and a radius $O'M$ draw the required circle MSQ.

PROJECTION OF THE SPHERICAL TRIANGLE.

In the six cases that may arise in the solution of spherical triangles, I have selected three, to illustrate the application of the constructions given to the projection of the spherical triangle.

CASE 1.

Given A 105°, c 30°, a 75°.



Place A at the center of the primitive circle (see Plate VIII), two sides of the triangle will then project as straight lines passing through the center of the primitive circle, making an angle of 105° with each other. Lay off MAC equal to one 105°. This projects the angle A. Lay off AB equal to c, equal to 30°. Then if with B as a pole, and polar distance equal to the value of the remaining side a, or 75°, a circle be projected, the intersection of this circle with PQ will determine the third vertex C. CLC' is this circle. It intersects PQ in two points: C and C', thus giving the two solutions. The centers of the arcs BC and BC' are found by constructing the locus of all great circles passing through a common point, B. This gives the line DF. Then repeat the same construction for C and C'; this will give the lines $O''''H$ and SV. The intersections of $O''''H$ and SV with DF determines the centres O''' and O'''', since if a point lies on two lines it will lie at their intersection.

The perpendicular required by Napier's Rules would be drawn from B to side b; the center of this circle lies on PQ, since it is at right angles to it, and also on DF, hence at their intersection. It may fall outside of the drawing, as in the present instance.

Suppose, however, that Bp is this perpendicular. Then, in solving by Napier's Rules, the side b is obtained by solving for Ap and Cp. Then b equals $Ap \pm Cp$. This is very clearly shown in the figure.

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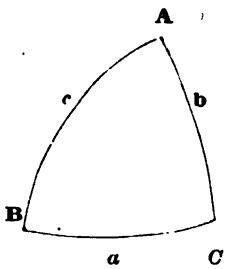
Since BC equals BC', CBC' is isosceles, and Cp equals $C'p$, and CA equals b, equals $Cp - Ap$, also $C'A$ equals $C'p + Ap$, equals $Cp + Ap$.

The projection of a triangle will often enable one to decide whether an angle or side is greater or less than 90°, and being a graphical representation, it shows at a glance the relations of the several parts of the triangle, especially where two solutions occur.

CASE 2.

Given A equal to 105°, b 52° 30′ and B 60°.



Put A at the center (see Plate IX.) Draw the principal diameters, EF and CD. Lay off EAQ equal to 105°. Find projection of vertex C, by theorem B. Now construct the polar triangle of the given one as follows: From the definition of polar triangle it is evident that C' is one vertex and B'' another, hence $C'B''$ is one of its sides. If with C as a pole, the great circle $B''A''A'$ be described, it will give the direction of another side, and since the sides of the polar triangle are the supplements of opposite angles in the required triangle, the length of third side must be equal to 180°—60°, equal 120°.

If then with C' as a pole, we project a circle of polar distance 120°, the third vertex will lie on it, but it also lies on $B''A''A'$, hence the following construction. Lay off $C'W$ equal to 120°; draw a tangent WO', and since $C'D$ is the line of measures of the required circle, O' will be its center and $O'W$ its radius. Draw $WA''A'$; it intersects $B''A''A'$ in A'' and A', giving two solutions, $A''C'B''$ and $A'C'B''$, hence the required triangle has two solutions. The centres O'' and O''' of arcs $C'A''$ and $C'A'$ lie in EF and LM, and are found by drawing a perpendicular to the chords DA'' and DA'. The third vertex of required triangle is found by projecting two circles, with A'' and A' as poles, and a polar distance equal to 90°; the centers of these are O'''' and O'''', and the two solutions are ACB and ACB'.

CASE 3.

Given A 75°, B 60° and C 120°.

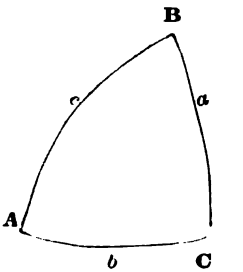


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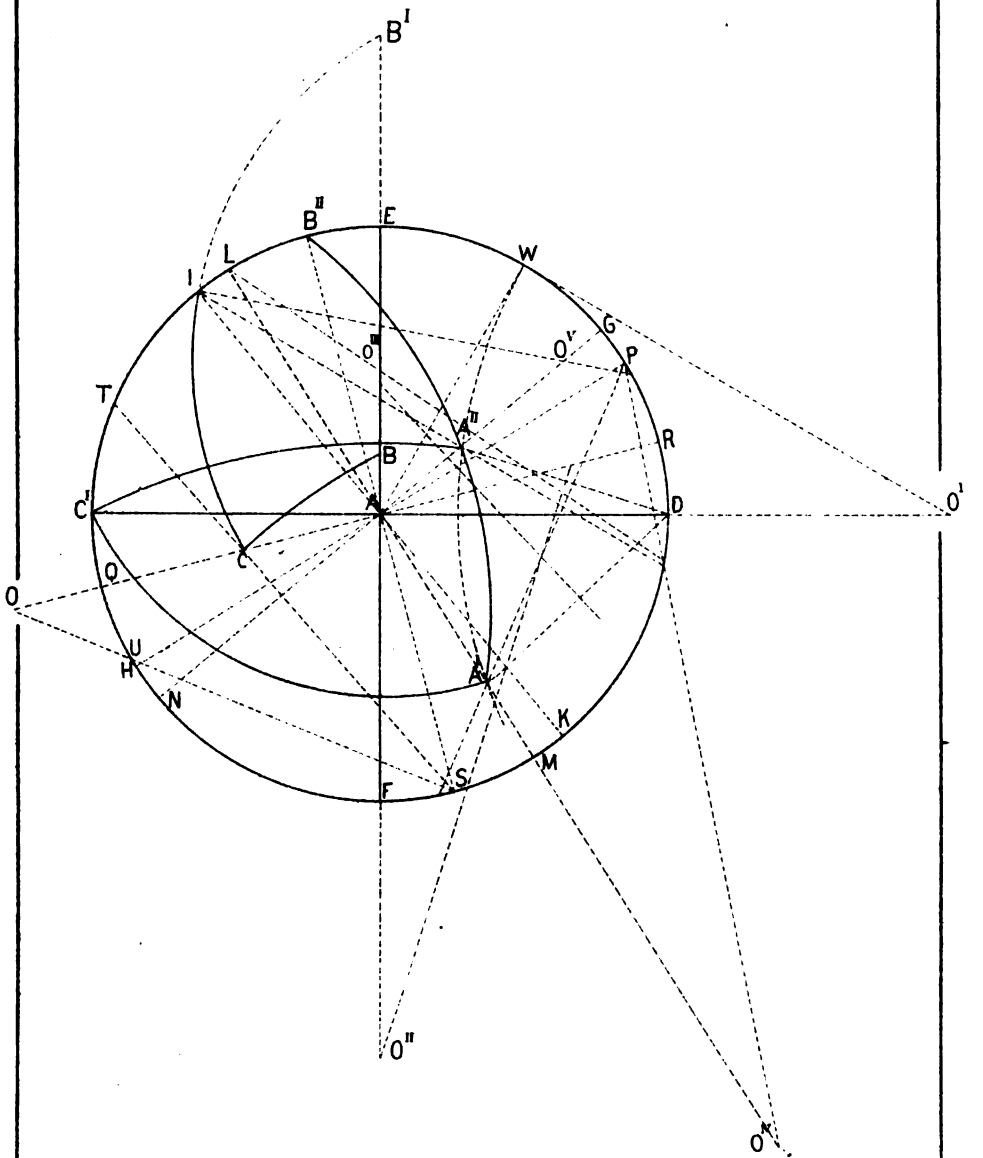
PLATE IX



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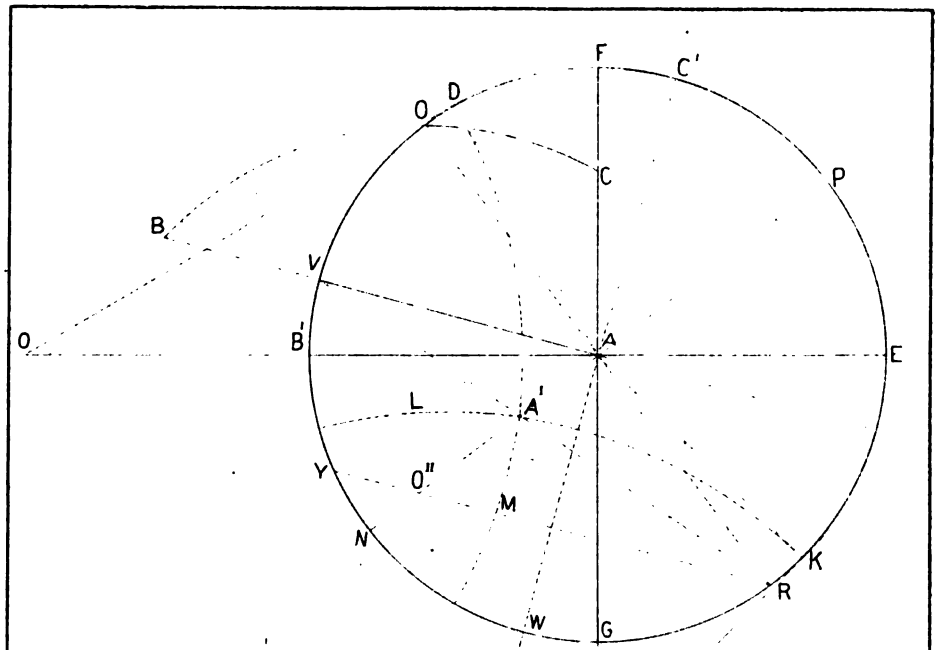

Fig. 1.

PLATE X

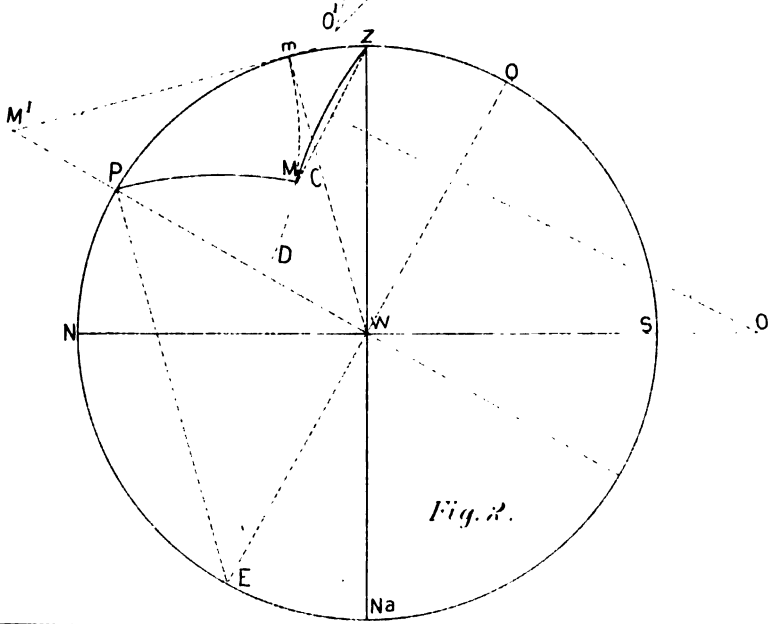

Fig. 2.

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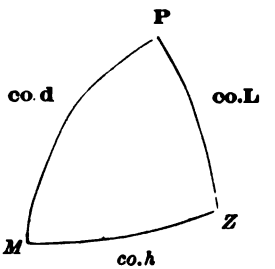
Place A at the center of the primitive circle, Fig. 1, Plate X, and so project the triangle that C will fall on vertical diameter through the center and above, and B to the left. Construct FAV equal to 75°; draw $C'W$ at right angles to VA. Then B' and C' are vertices of the polar triangle, and $B'C'$ one of its sides. The remaining sides will be equal to 180°—B, and 180°—C, or 120° and 60°. If, then, with B' and C' as poles, circles be projected with polar distances of 60° and 120° respectively, their intersection will determine the third vertex of the polar triangle. The tangent lines DO and KO' determine the centers O and O' of these circles. Then with radii OD and $O'K$ draw arcs intersecting in A', the third vertex of polar triangle. Finally, with A' as a pole and a polar distance of 90 degrees, project a circle. The construction is: draw RQ at right angles to NP; draw RA' and produce to V; lay off VY equal to VQ; draw RY intersecting NP in O'', the center of required projection. Then with radius $O''Q$ draw CQB. ABC is the required triangle. The required angles of any triangle may be measured by drawing the tangents to the intersecting circles; the sides may be measured by projecting the polar triangle and measuring its angles in the same manner.

In Fig. 1, Plate VI, let P be the elevated pole of the heavens (that pole which is above the horizon of any place is called the elevated pole); draw PA; let $B'AE'$ be the equator. PE is the altitude of elevated pole; but PE measures the angle PAE and is therefore equal to the latitude of P.

Hence the latitude of any place is equal to the altitude of the elevated pole.

Projection of the Astronomical Triangle.

Given lat. 30° N., the declination of a heavenly body 45° N., and its hour angle 45° W.



Let P be the pole of the heavens, Z the zenith and M the body. Then, as indicated in the diagram, we have given two sides and the included angle. Let it be required to project it on the plane of the meridian. Let ZNS, Fig. 2, Plate X, be the primitive circle; Z is the zenith; Na the nadir; N and S the north and south points; E and W the east and west points, the east point being the point of sight. Construction: Lay off ZP equal to the co-latitude, equal to 60° N. QE is the locus of centers of all great circles passing through the point P. The center of the one making an angle of 45° with the primitive circle is at E. Then, with E as a center and EP as a radius, draw PC.

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This will be another side of the required triangle. Since the length is *co d*, or 45°; if, with *P* as a pole and a polar distance of 45°, a circle be projected, it will intersect *PC* 45° from *P*, thus determine the vertex *M*. In this case the pole is on the circumference of the primitive circle. Lay off *Pm* equal to 45°, draw a tangent to the primitive circle at *m*, and its intersection with *WP* at *M'* gives the center. Then, with radius *M'm*, draw *mD*, intersecting *PC* at *M*. Now pass a great circle through *Z* and *M*. This is most readily done by drawing a perpendicular to the chord *MZ* at its middle point and finding its intersection with *NS* at *O*. With *O* as a center and a radius *OZ*, draw *ZM*. *PZM* is the required projection.

To project the same triangle on the plane of the horizon:

Let *NWSE*, Plate XI, Fig. 1, be the primitive circle. *Z*, the zenith, will be the center, and the nadir the point of sight. Construction: Lay off *ZP* equal to co-latitude, equal to 60°. *AB* is the locus of all great circles passing through *P*. Draw *PO*, making *OPZ* equal to 45°; then, with *O* as center and radius *OP*, draw *PM*. Then, as in preceding construction, project a circle with *P* as pole and polar distance equal to side *PM*. Then join *MZ* by a straight line. *PZM* is the required triangle.

As a further illustration, the following problem is given: Let it be required to project the sphere on the horizon of a place in 30° N. latitude and 0° longitude, showing the meridians 45° and 90° east and west; the parallels, 60° N. and 60° N. and 30° S., project the equator and join the point *A* (lat. 60° N. and long. 90° E.) with the point *B* (lat. 30° S. and long. 45° E).

ENWS, Plate XI, Fig. 2, is the horizon, *N* the north point, *E* the east, etc. The zenith *Z* falls at the center. *P* is the elevated pole, 60° from *Z*. All meridians pass through *P*; hence, to project any meridian, find *O'O''*, the locus of the centers of all great circles passing through *P*. *O'PED* is the one 90° E. and 90° W., with center at *O*; *PBD* and *PGD* are the ones 45° E. and 45° W., with centers at *O* and *O''*, respectively. The parallels 30° N. and 60° N., are projected with *P* as a pole, and a polar distance equal to 60° and 30°, respectively. The parallel 30° S. projects into the line *O'O''*, since its polar distance is equal to the supplement of its inclination. The points *A* and *B* are joined by finding the locus of all great circles passing through *A* and *B*, and taking their intersection at *O'' V''*, as the center, and the radius *OA*, and drawing the arc *AB*.

Map Projection.

As it is impossible to represent exactly the earth's surface upon a plane, its figure not being one that admits of development, various methods have been devised for projecting it, with more or less accuracy, each having some advantage peculiar to itself. Only the polyconic method will be here considered, and the shape of the earth assumed

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PLATE XI

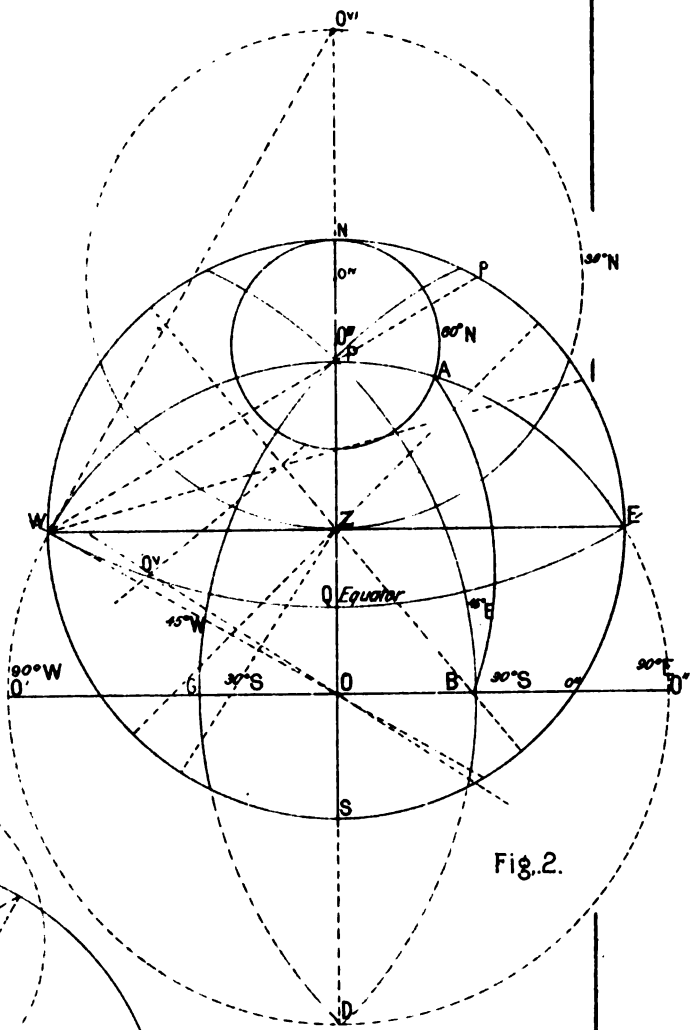

Fig. 2.

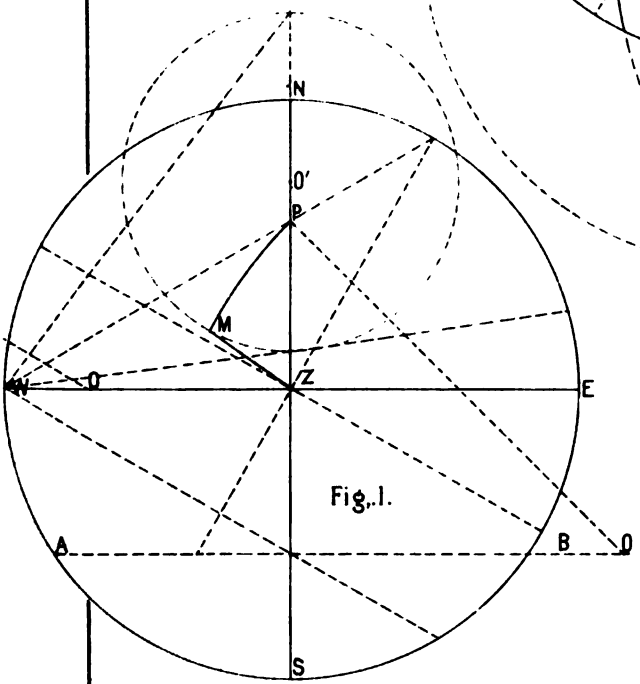

Fig. 1.

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to be that of a spheroid, the values of the semi-axes being those deduced by Col. A. R. Clark, R. E., at the British Ordnance Survey Office in 1866, viz:

a=6,378,206.4 meters, b=6,356,583.8 meters;
a : b : : 294.98 : 293.98.

The following is quoted from the U. S. C. & G. Survey Report for 1884, viz: "So nearly have these elements been found to represent the curvature and magnitude resulting from the trigonometrical work of the Coast and Geodetic Survey, that no subsequent change in the general dimensions would so far affect the territory of the United States as to make it useful to seek a better general surface of projection for this country."

If a cone be passed tangent to the earth's surface, along a given parallel of latitude, and the cone then developed, the parallel will develop into a circle, with center at the vertex of the cone, and radius equal to the tangent of the pole distance of the parallel. Now if, in a similar manner, a cone be passed tangent to each parallel, within the limits of the map, each cone developed, and the developed intersections of each meridian with all the parallels found, and the meridians drawn through these points, the projection so obtained is called polyconic. It is of that general class of projection called developments.

The method may be applied to the entire spheroid, and the successive positions of the tangent cone traced as follows: at the north pole it becomes a tangent plane, the radius of the developed parallel being zero; now proceeding along an assumed central meridian, the cone being passed tangent to successive parallels, its vertex, or the center of the developed parallel, recedes along the prolongation of the earth's axis. At the equator the cone becomes a tangent cylinder, the radius of the development becoming infinite. Hence the projection of the equator becomes a right line, perpendicular to the central meridian, all the other parallels are also perpendicular to the central meridian and concave to the equator. Passing beyond the equator towards the south pole, the vertex of the tangent cone passes from an infinite distance beyond the north to an infinite distance beyond the south pole, and then proceeds towards the earth, until, when the cone becomes a plane, it coincides with the south pole. There thus results a figure that is symmetrical with reference to two axes, at right angles to each other, these axes being the central meridian and the equator.

The polyconic method as outlined above has the following general properties:

(1) The meridians and parallels are perpendicular to each other as in space.

(2) The scale along the central meridian and the parallels is accurate; in other directions nearly so.

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(3) The distortion of areas is not excessive. It increases towards the limiting meridians.

(4) It is impossible to have the meridians and parallels at right angles to each other, and preserve the equality of areas. Either must be sacrificed to some extent, usually the latter.

Construction of Maps.

Having determined the limits of latitude and longitude of the area to be projected, and the scale of the map, draw the central meridian, assume the intersection with it of the extreme northern parallel. From this point lay off the actual arc of the meridian to the central and extreme southern parallel; draw through these points, with great accuracy, perpendiculars to the central meridian. Since in any practical case the center of the developed parallel is inaccessible, it becomes necessary to plot the developed intersections of the meridians and parallels by means of coördinates. (The formulas to obtain these will be given later. See page 34). Lay off the coördinates X along these perpendiculars, and through these points lay off the coördinates Y parallel to the central meridian. This will give three points on each meridian, and though their projections are curved lines, in any map not covering more than two hundred square miles, it will be impossible to detect the curvature, hence straight lines through these points will determine the meridians usually. Next divide the distance between the points Y on the meridians into a number of equal parts whose value shall be the same as the interval between the meridians. Through the points thus obtained draw curved lines to represent the parallels.

Deduction of Formulas for the Construction of Tables.

Since the earth may be assumed, for the purposes of map projection, to be a spheroid, the meridians will be ellipses, the semi-axes as given above. The parallels of latitude are circles, since they are the intersection of a surface of revolution by a plane at right angles to the axis of revolution.

Radius of Curvature of Meridian.

Let R be radius of curvature of the meridiun, then

$$R = \frac{\left\{1+\left(\frac{dy}{dx}\right)^2\right\}^{\frac{3}{2}}}{\frac{d^2y}{dx^2}} \quad (1)$$

Differentiating $a^2y^2+b^2x^2=a^2b^2$, substituting and reducing we get,

$$R = \frac{(a^4y^2+b^4x^2)^{\frac{3}{2}}}{a^4b^4} \quad (2)$$

To find x^2 and y^2, let *P* plate XII be any point on the surface of the earth; A B C the meridian obtained by passing a plane through P and

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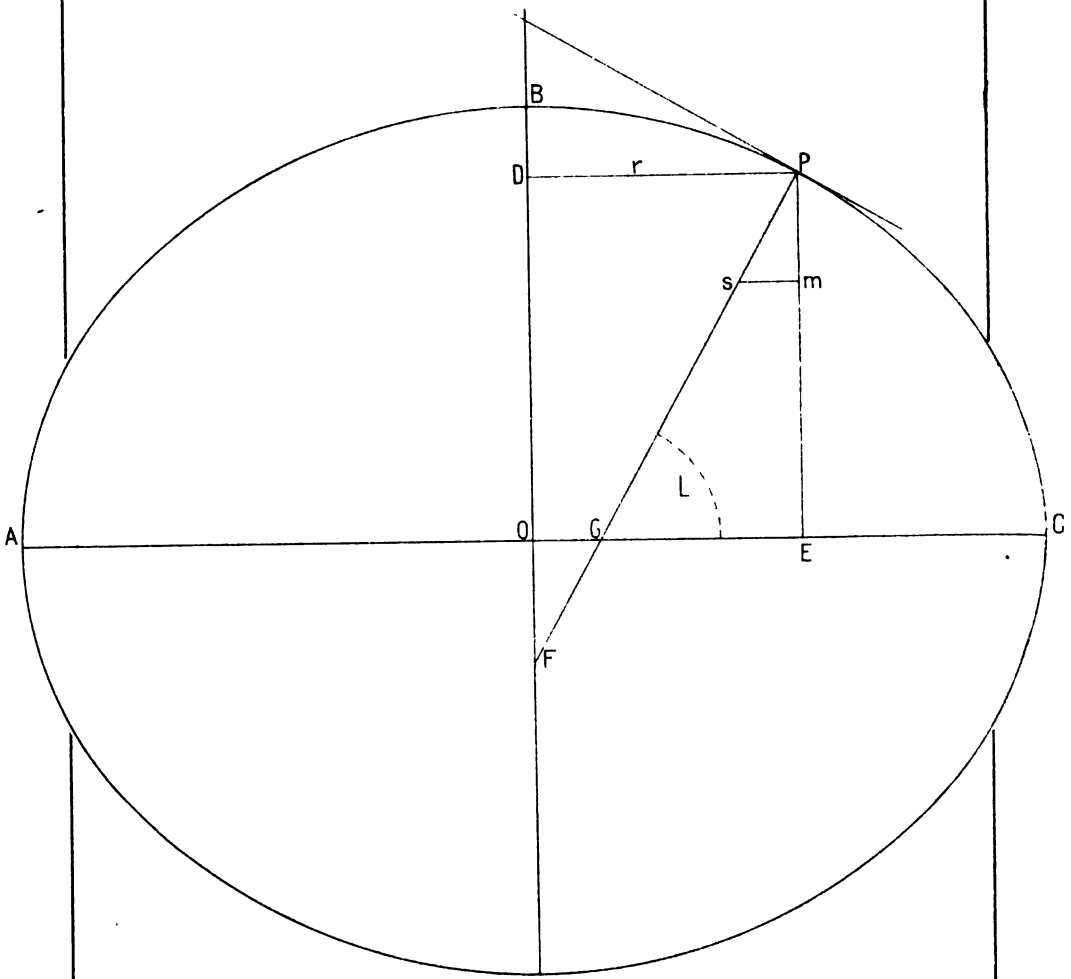
PLATE XII



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the center of the earth. PF the normal, PGE the latitude of the point P. Since ABC is an ellipse we have

$$\frac{OE}{GE}=\frac{a^2}{b^2}, \text{ or } \frac{x^2}{\overline{GE}^2}=\frac{a^4}{b^4}$$

$$\text{But } \overline{GE}^2=y^2\cot^2 L=\left(\frac{a^2b^2-b^2x^2}{a^2}\right)\cot^2 L.$$

$$x^2=\frac{a^2(a^2-x^2)\cot^2 L}{b^2} \quad (3.)$$

Solving (3) for x^2,

$$x^2=\frac{a^4\cot^2 L}{b^2+a^2\cot^2 L}$$

$$\text{or } x^2=\frac{a^4\cos^2 L}{b^2\sin^2 L+a^2\cos^2 L} \quad (4.)$$

From plate 12,

$$y^2=\overline{GE}^2\tan^2 L.$$

$$=\frac{b^4}{a^4}\overline{OE}^2\tan^2 L.$$

Substituting value of $\overline{OE}^2$ from (4), and reducing we get

$$y^2=\frac{b^4\sin^2 L}{b^2\sin^2 L+a^2\cos^2 L} \quad (5.)$$

Substituting x^2 and y^2 from (4) and (5) in (2) and reducing.

$$R=\frac{a^2b^2}{(b^2\sin^2 L+a^2\cos^2 L)^{\frac{3}{2}}}=\frac{a^2b^2}{\{(a^2-b^2)\cos^2 L+b^2\}^{\frac{3}{2}}}$$

Let e equal the eccentricity of the meridian then

$$a^2-b^2=a^2e^2 \text{ and } b^2=a^2(1-e^2)$$

substituting and reducing we get

$$R=\frac{a(1-e^2)}{(1-e^2\sin^2 L)^{\frac{3}{2}}} \quad (6)$$

Length of normal to transverse axis.

On *PE* Plate XII lay off *Pm* equal to dy; draw *ms* parallel to *AC*, then since *PG* is the normal, *ms* equals dx, and *Pm* equals dy, and $PS=\sqrt{dx^2+dy^2}$.

$$\frac{PG}{PS}=\frac{PE}{Pm}$$

$$\text{or } PG=y\sqrt{1+\left(\frac{dy}{dx}\right)^2} \quad (7)$$

Substitute the value of $\frac{dy}{dx}$ in (7), and in the resulting equation substitute the values of x^2 and y^2 from equations (4) and (5). After reducing we get

$$PG=\frac{b^2}{(b^2\sin^2 L+a^2\cos^2 L)^{\frac{1}{2}}} \quad (8.)$$

Length of normal to intersection with minor axis.

The normal is now PF Plate XII, equal to N. say:

$$\frac{PG}{GF}=\frac{GE}{GO} \text{ or } \frac{PG+GF}{PG}=\frac{GE+GO}{GE} \text{ or } \frac{PF}{PG}=\frac{OE}{GE}=\frac{a^2}{b^2}. \quad \therefore N=PG\times\frac{a^2}{b^2}$$

Substitute the value of PG from (8), and we get:

$$N=\frac{a^2}{(b^2\sin^2 L+a^2\cos^2 L)^{\frac{1}{2}}}$$

or reducing and substituting the value of e, as before,

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$$N=\frac{a}{(1-e^2\sin^2 L)^{\frac{1}{2}}} \text{ (I.)}$$

Comparing (I) with (6) we get:

$$R'=N^3\left(\frac{1-e^2}{a^2}\right) \text{ (II.)}$$

Let r be radius of the parallel, through P, or PD, then from plate *XII.*

$$r'=N\cos. L \ (III.)$$

Let r′ be the radius of developed parallel, or slant height of tangent cone, then,

$$r=N\cot L \ (IV.)$$

Let l be the length of an arc of the parallel, C the angle it subtends at the vertex of tangent cone when developed, C′ the angle it subtends at the center of parallel before development.

Then,

$$C=\frac{l}{r'} \text{ and } C'=\frac{l}{r}$$

$$\therefore \frac{C}{C'}=\frac{r}{r'}=\frac{N\cos L}{N\cot L}=\sin L.$$

$$\text{or } C=C'\sin L \ (V.)$$

In plate XIII, *V M* is the central meridian, *V* the vertex of tangent cone, and *A D* the corresponding developed parallel. If *P* be the developed position of intersection of the parallel with a given meridian, then the coördinates of *P* are O n=x and n P=y, and evidently

$$\left.\begin{aligned} x&=r'\sin C \\ y&=2r'\sin \tfrac{1}{2}C \end{aligned}\right\} \text{ VI.}$$

Regrouping the preceding formulas we have

Normal produced to Minor Axis	$N=\frac{a}{(1-e^2\sin^2 L)^{\frac{1}{2}}}$ (I.)
Radius of Curvature of Meridian	$R=N^3\left(\frac{1-e^2}{a^2}\right)$ (II.)
Radius of Parallel	$r=N\cos L$ (III.)
Radius of Developed Parallel	$r'=N\cot L$ (IV.)
	$C=C'\sin L$ (V.)
Coördinates of Curvature	$x=r\sin C, y=2r\sin\frac{1}{2}C$ VI.

Length of 1 min. of meridian $=R\,(60\sin 1'')$

$$=\frac{a\,(1-e^2)\times(60\sin 1'')}{(1-e^2\sin^2 L)^{\frac{3}{2}}} \text{ VII}$$

Length of 1 min. of parallel $=r\,(60\sin 1'')$

$$=\frac{a\cos L\,(60\sin 1'')}{(1-e^2\sin^2 L)^{\frac{1}{2}}} \text{ VIII}$$

From these, tables for map construction may be computed. Equations I to VI are of the form given in the U. S. C. and G. Survey Report for 1884, Appendix No. 6. In the same report extended tables are given, covering every case form 0° to 90° latitude.

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PLATE XIII

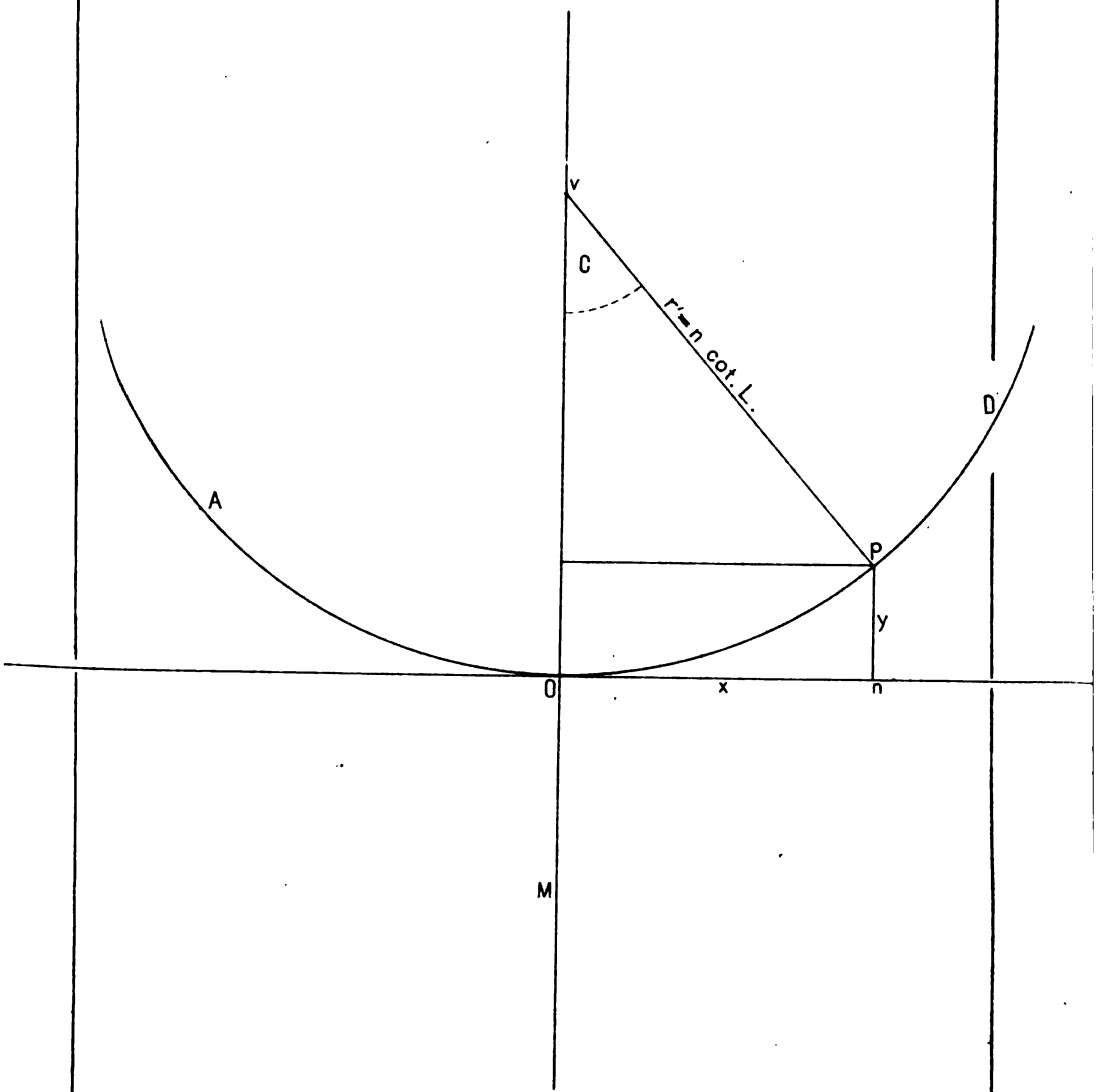

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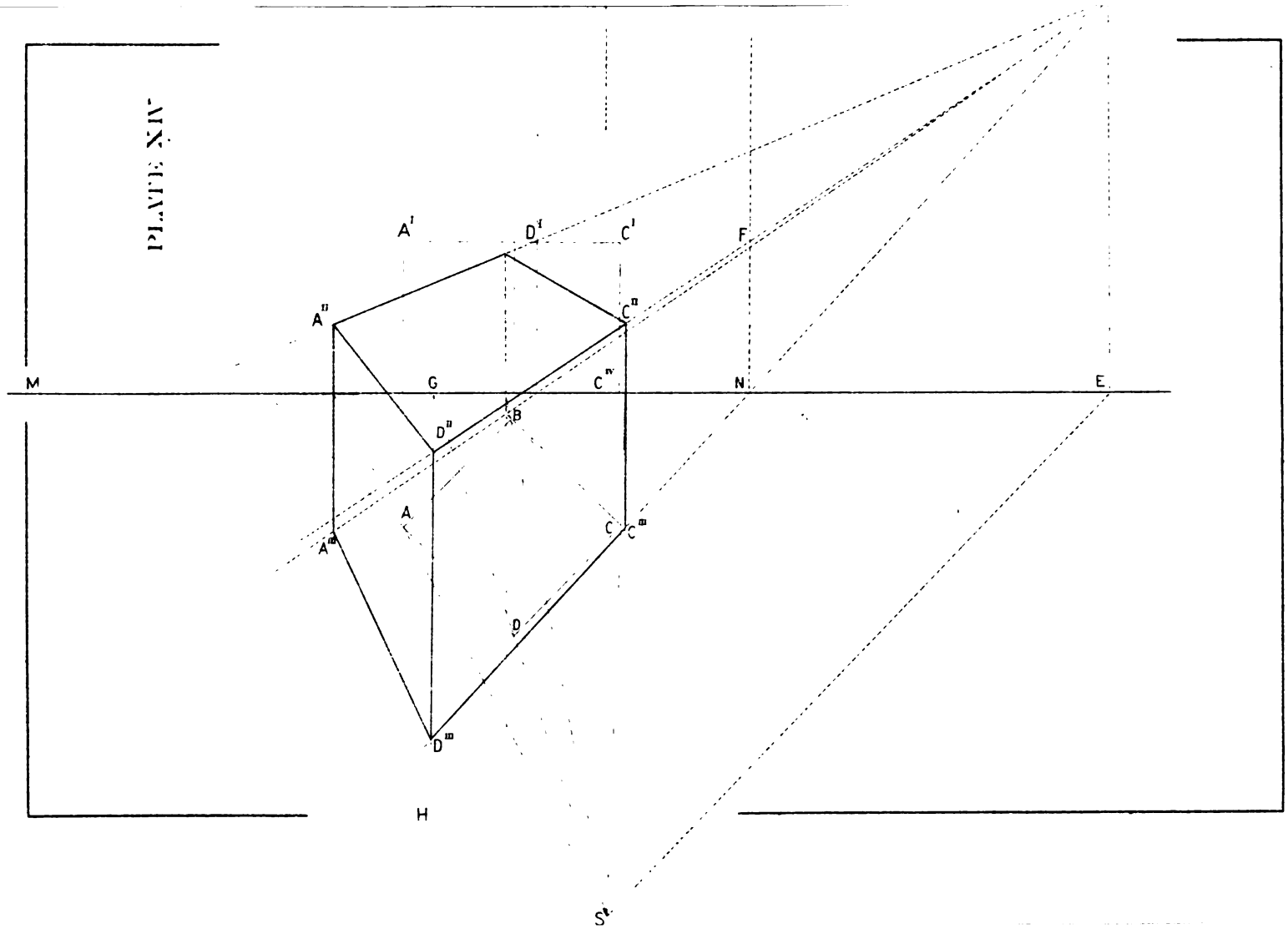
PLATE XIV



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Perspective.

If the point of sight be at some finite distance from an object the projection is called Scenographic, and gives a perspective of it. That is it represents an object as it appears to be, not as it really is.

Definitions. A visual ray is a right line drawn through the point of sight.

A plane of rays is one passed through the point of sight.

The plane upon which the perspective is made is called the plane of the picture.

The intersection of the horizontal plane of rays with the plane of the picture is called the horizon.

Having determined the relative positions of the point of sight, plane of picture and object, the perspective of any point of the object is where the visual ray through the point pierces the plane of the picture.

If a plane of rays be passed through any right line its intersection with the plane of the picture is the perspective of the line.

It follows from this definition that the perspective of a vertical line is parallel to the line itself; also, that the point where any line of the object pierces the plane of the picture is a point in the perspective of the line.

If a visual ray be drawn parallel to a right line or system of parallel right lines of an object, the point where it pierces the plane of the picture is called the vanishing point of the line, or of the system of parallel lines. If the line or system be horizontal, as is usual in any practical problem, the vanishing point is in the horizon.

The vanishing point of a right line or a system of parallel right lines is evidently the perspective of the infinitely distant point in which the line or each line of the system intersects the parallel visual ray. Hence the vanishing point of a line or system of parallel lines is a point in the perspective of each of them.

The perspective of any line may then be found by joining the point where it pierces the plane of the picture with its vanishing point.

The perspective of curved lines may usually be found by drawing auxiliary lines such as tangents and diameters, and finding the perspectives of them and sketching in the perspective of the curve.

If it be a circle its perspective will in general be an ellipse whose axes can be readily determined and points on its circumference constructed.

It is believed that the above statements in *italics* can be made to cover every construction in perspective that may arise in the practice of mechanical draughting.

These are illustrated in the following examples.

Let AC and $A'C^{IV}$ be the horizontal and vertical projection of a cube. (See plate XIV) S and S' the projection of the point of sight. MN the ground line or horizontal trace of the plane of picture. S' V will be the horizon. Through S draw SE parallel to DC; it pierces plane of picture in the horizon at V. V is therefore the vanishing point of DC and AB. DC pierces plane of picture at F, and VF

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is the perspective of DC. The perspective of D is where the ray through D pierces the plane of the picture. Draw the horizontal projection of this ray SD, produce it to the ground line, at the point of intersection G draw GH perpendicular to it and the point where the ray SD pierces the plane of the picture (*i. e.* the perspective of D) will be somewhere on it. Since it lies on two lines it must be at their intersection, hence D″ is the perspective of D. The construction may be summarized thus: Find the vanishing point of the line; find where the line pierces the plane of the picture. The line drawn these two points is the perspective of the given line. To find the perspective of any point on this line draw visual ray through it, produce it to horizontal trace of the plane of picture, at this point draw a perpendicular, where it intersects the perspective of the line is the perspective of the point.

The following arrangement of the parts of this perspective as on plate XV gives more satisfactory results. Obviously we may place the line S′ V anywhere we like, provided we keep the relation between the points S, S′ and V unchanged. Let S, MN and ABCD, Plate XV represent the same as on Plate XIV. Let EFGH be the elevation of the cube, and XY the horizon. (This figure may be on any convenient part of the paper, or on another sheet entirely.) Through S draw ST parallel to DA, at T draw TW perpendicular to MN. Through any point H draw HH parallel to MN, and take this as the horizon line. To get the perspective of DA draw SDD″, then D″ K perpendicular to the ground line MN; produce DA to A″, draw A″ L perpendicular to MN, from O lay off OL equal to YF; draw HL and produce it to intersection D′ with D″ K. HD′ is the perspective of DA and D′ of D. To get A draw SA, produce to R, draw the perpendicular RA′ and its intersection A′ with HL is the perspective of A. Thus the perspective of the object can be made to fall in a convenient place on the sheet and the confusion of lines in plate XIV avoided.

It will not usually be necessary to use more than one vanishing point.

The following convenient device enables the draughtsman to use an inaccessible vanishing point. In Plate XVI let FG represent the drawing-board, MV the horizon, V the vanishing point. A is a piece of half-inch stuff, AA the arc of a circle, with center at V, radius VN. B is a T-square, the head B is of same material as A and formed by same saw cut. C is the blade of the T-square. The piece A is glued or tacked to the drawing-board, being adjusted to the horizon line. The radius VM being the difference between MN and MV is known, the arc AA should be long enough to include the highest and lowest lines in the object.

Respectfully submitted,

LOUIS H. BARNARD,
Professor of Civil Engineering.

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PLATE XV

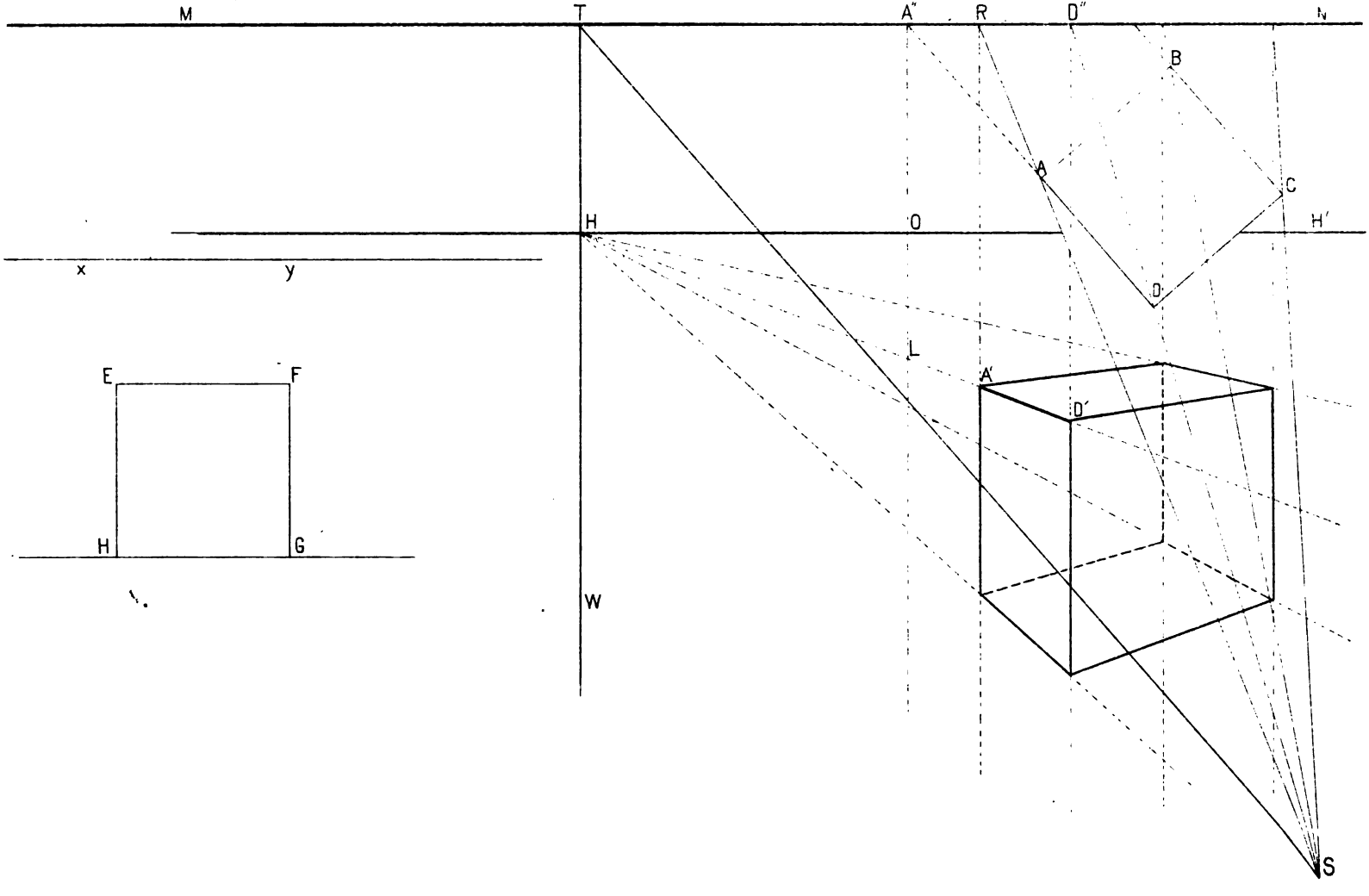

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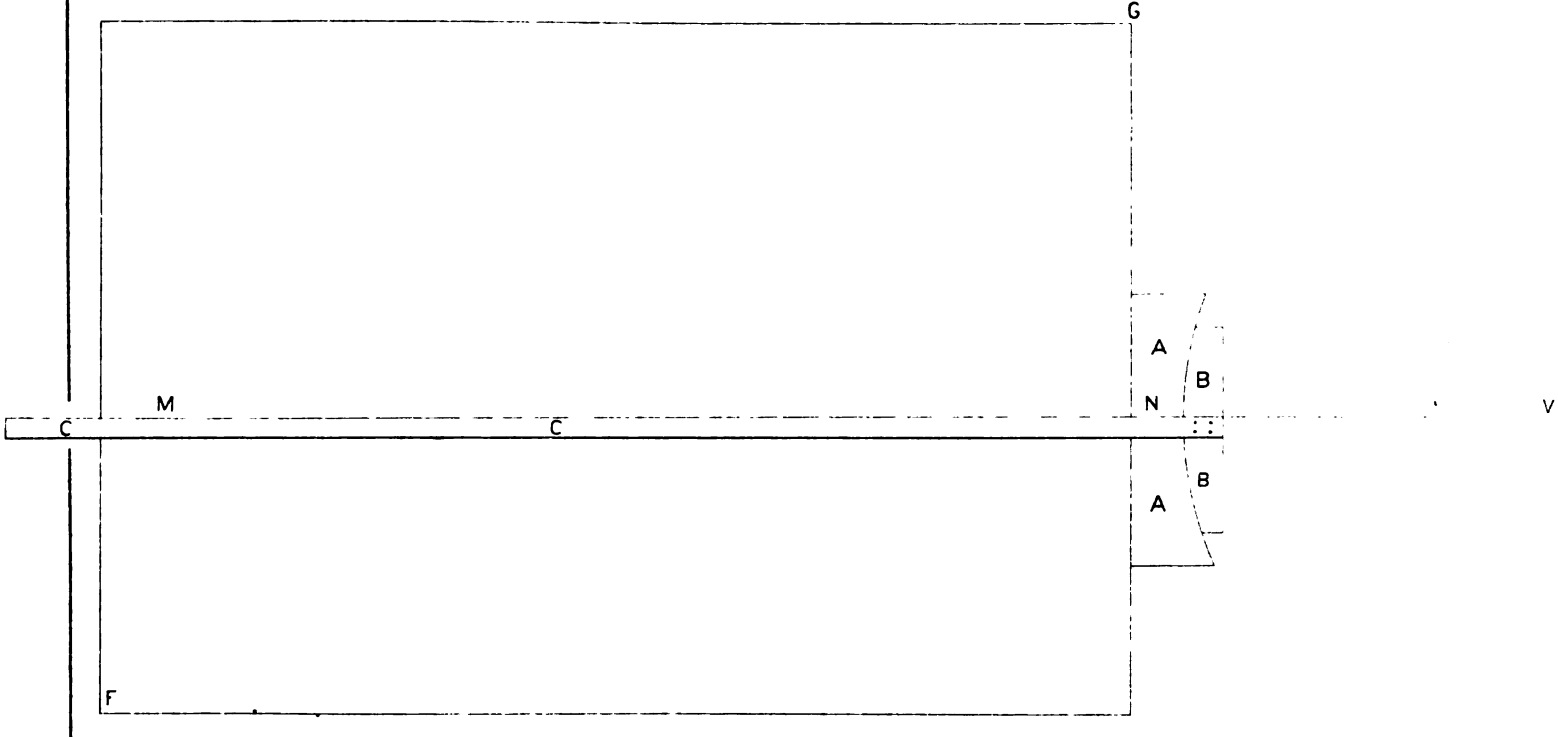
PLATE XVI



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6. MENTAL AND MORAL SCIENCE, AND ENGLISH LITERATURE.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: The work of my department was, at the first of February last, seriously threatened by my illness; but within a few days, through the kindness of three of my colleagues, provision was happily made for most of my classes. In brief, the arrangements made were as follows: one class (special) was dropped altogether, and another class (Sophomore Latin, three hours per week) was transferred to the spring session by an exchange with Professor Reeves; two classes (Rhetoric and Moral Science, four hours each) were given full hours of instruction by Professors Jackson and Heston, and one class (Freshman Latin, five hours) was taught by Professor Herrick, whose regular duties however did not permit him to give the allotted time. No exchange was made with a view to my making up this lost time in the spring session, and such an exchange would hardly have been feasible, as I taught seventeen hours per week during that session, besides giving four hours per day to my work in the president's office. In the fall session, my work (nineteen hours per week) was more enjoyable to me, inasmuch as it was done under no disadvantages, but it had no features of special interest.

The blackboard surface in the class-room is rough and broken, and should be repaired at once if the room were otherwise suitable: as it is too small for the classes, one of which numbers twenty-two, I renew my request that there be assigned for my work a larger and more commodious class-room, with a small office attached. Number 218 and room adjoining illustrate the combination that would be desirable, and I trust that some such provision will be made before the opening of the next college year.

The appropriation of last year ($50.00) for the purchase of charts, atlases, etc., is unexpended. The reason for this surprising fact is as follows: Some of the material was not found to be obtainable in the form desired, and replies to inquiries came very tardily, some questions having been answered since the close of the year and others remaining yet unanswered; it therefore seemed probable that the money could be better distributed and more wisely expended after the receipt of full information on all points involved. Accordingly, although one small purchase had been made, I decided to leave the appropriation untouched, and to ask, as I now most earnestly do, that the grant be renewed, and that I be authorized to have some charts made to order, if this seem desirable.

I desire to repeat the statement of my last report, that the college

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library is almost wholly destitute of books suited to the wants of my department. Now that provision has been made for the great and pressing needs of the technical courses, and that the growth of my classes has made more evident the inadequacy of my library to supply their wants, I must urge the request previously withheld in deference to the greater wants of others. Let me illustrate briefly the needs of but one branch of my work. The objects commonly sought in the study of English literature are three, an intelligent, appreciative enjoyment of good literature, that culture which has been claimed so often as the exclusive product of training in the Greek and Roman classics, and an analytical and critical acquaintance with the treasures of our mother tongue. The first of these results is usually obtained through or in connection with the other two; and those two require that the student have access to such aids as are possessed by classical students, dictionaries, standard editions of early works, and all that is needful for a right understanding of the historical, mythological and other allusions in a work read, for a full presentation of the rhetorical, dramatic, and metrical laws which may affect its structure, and for a clear conception of the life of the author and his relation to the times in which he lived.

Permit me to call attention again to a line of instruction related to my work though not included in it, practice in English composition. In an institution such as ours, there is a constant call for men and money in the higher parts of the courses and especially in the purely technical studies, and, in the face of this pressure that tends to dwarf or starve all lower-class work, it is not surprising that no special provision has been made for the subject named. Accordingly, the essay work is distributed, session by session, among the professors who seem to be least burdened. The disadvantages of this arrangement are so great and so well known to you that I trust you will urge and the board will make provision for the appointment of a professor who, while taking charge of rhetoric and the theory of expression, shall secure to each student, throughout his college course, regular, progressive, and appropriate practice in the different forms of composition, and, in general, shall aid his pupils in gaining both excellence of style and facility in the oral and written expression of thought. With the duties of this professorship might be combined instruction in Anglo-Saxon and some other kindred work; but I believe that the duties previously named would, of themselves, fully justify the employment of the additional professor.

Another tendency to be guarded against in polytechnic colleges is that towards filling the technical courses with studies that are wholly technical, to the rigid exclusion of those studies that train for manhood and citizenship rather than for professional life. You have undoubtedly noticed this tendency elsewhere; the illustration which I would give is in connection with the study of logic. I have urged

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above that the college should develop in all students the power of expressing thought; not less important is it to develop the power of thinking, and especially to make scientific students familiar with the methods of inductive thought that direct scientific investigation and underlie the advances of modern research. Logic, then, as "the indispensable foundation and an ever-present though often hidden factor in all good thinking and writing," has valid claims to a place in every course which leads to a diploma.

Realizing that many subjects are now claiming your attention, I have nevertheless asked your consideration of the changes suggested in this report, from an earnest conviction that they will, if adopted, prove beneficial to the institution.

Respectfully submitted.

JAS. Y. MCKEE.

STATE COLLEGE, PA., *January 15, 1889.*

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7. HORTICULTURE.

GEO. W. ATHERTON, LL. D., *President:*

SIR: I have the honor to submit this, the report of the work of the Horticulture Department for the year 1888, together with additional instruction.

During the winter term of this year a class in Free-Hand Drawing, of twenty-five members, was under my direction. The work assigned to the students begins with straight and curved lines, passing into surfaces involving forms that illustrate symmetry, equality, regularity and beauty in outline. Then follows drawing of objects. This last is a difficult step for those students who have but little aptitude in representing things as they see them. It is quite common to find persons making a picture of a cube to show five of it sides and attempting to make all the angles, right-angles in drawing. To aid in making the transition from surfaces to objects, sometime is spent in drawing from copies, before the objects are given to the students. Some drawings are made from memory, such practice being a good test of the power of perception and tending to originality of representation.

The importance of this work is being appreciated more and more as we advance in the work of education, for no verbal description will serve to convey, so perfectly as a good drawing, the conception of any object; and, whatever science is studied, nothing will leave a better impression upon the mind of the student than a drawing by his own hand of the things he sees. The work of this class is continued throughout the spring term also.

A preparatory class of twenty members was under my instruction, in the study of zoology during the winter term, following the outline in "E. S. Morse's First Book in Zoology." The study was confined to the appearances and habits of the familiar animals, many of which were provided for the class to dissect, to prepare drawings from, or to mount upon cards for the cabinet.

In the spring term, beside the free-hand drawing above referred to, I had a preparatory class in botany, consisting of twenty-four members, and a class of eleven Freshmen in horticulture practicum. This work was principally out of doors, such as pruning vines, grafting apple trees and applying insecticides upon trees and shrubs found on the campus. With the assistance of this class, a list of all the trees and shrubs on the campus was made, to aid in familiarizing the student with the various ornamental materials used in beautifying grounds. The list will be found appended to this report. The students were then required to study and write out the history of these trees, their description, their usefulness for ornamentation, their value in the question of forestry and their propagation.

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In the fall term my work of instruction was as follows: A preparatory class of twenty-six members in physiology; class of seventeen Freshman in horticulture practicum, much of which, owing to the size of the class was necessarily in the form of lectures; a class of two Sophomores, taking one of the courses in agriculture, having lectures on advanced work in horticulture, and a class of eleven Juniors in botanical practicum, which is chiefly plant analysis.

In regard to other work of the department I would report as follows: The two small green-houses erected in the late fall of 1887 were put in operation in the latter part of March, 1888. About forty dollars worth of stock plants were purchased. These have been greatly multiplied by propagation. Some of the plants valuable for the conservatory are becoming too large for these small houses, but are retained in anticipation of the conservatory to be completed over the foundation already laid.

By the authority of the board we secured a gardener to do such work as requires skill and experience. The same individual to act as gardener to the Experiment Station. A very efficient workman was found in Mr. George Olley, whose services began April 1, 1888, and continued until November 5, 1888. At this time a serious disease made it impossible for him to carry on the work The place thus vacated is not yet filled, but it is expected that it will be by the 5th of January, 1889. Additional labor on the campus for the year, including the vineyard and orchard, has cost us $520. The appropriation for 1888 to this department was exhausted in the first seven months, and, although so much improvement is sadly needed on the grounds, nothing could be done to make the new buildings accessible by proper roads and walks. There has been a slight income to the department from produce. Extra care was given to the vineyard and an unusually fine crops was the result.

The income from the sales of the year was as follows:

Grapes,	2,112 lbs.	$67 81
Apples,	123 bus.	45 94
Cider,	736 gals.	54 19
Plants, flowers, etc.,		12 28
Total,		$180 22

Relative to the work of the coming year, I beg to call attention through this report to the immediate need of proper walks and drives on the college grounds communicating with the new buildings. So much additional territory has been added to the campus that a special appropriation for such new work is absolutely necessary. Before anything definite is done on the grounds, I would recommend that a plan of the entire place be prepared and adopted, by which any part of the grounds may be finished as belonging to a harmonious whole.

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It is true that the landscape of most American universities is the result of piecemeal work, as suggested by present convenience or fancy, and expensive changes have often been imperative. It is interesting to note that the Leland Stanford, Jr., University has adopted a general plan covering its 7,000 acres of property, and all buildings now being erected and to be erected in the future will be placed with reference to that plan.

An appropriation of $800 will be needed to carry on the work of the coming year, and if new work about the recent buildings is to be undertaken an additional sum will be required for it.

Respectfully submitted.

GEO. C. BUTZ.

STATE COLLEGE PA., *January 2, 1889.*

Following is a list of the trees and shrubs growing on the campus of the Pennsylvania State College, giving the botanical and common names, the number of each species, and the years when the trees were respectively planted, as near as could be determined with but little record:

BOTANICAL NAME.	COMMON NAME.	Year of planting.	No. of plants.
Abies Canadensis,	Hemlock spruce,	1860	6
Abies Canadensis,	Hemlock spruce,	1888	4
Abies excelsa,	Norway spruce,	1860	27
Abies excelsa,	Norway spruce,	1875	18
Abies excelsa,	Norway spruce,	1882	1
Abies excelsa,	Norway spruce,	1887	2
Abies balsamea,	Balsam fir,	1878	8
Acer platanoides,	Norway maple,	1872	144
Acer platanoides,	Norway maple,	1876	8
Acer platanoides,	Norway maple,	1888	4
Acer dasycarpum,	Silver maple,	1860	24
Acer dasycarpum,	Silver maple,	1881	1
Acer rubrum,	Red maple,	1882	4
Acer rubrum,	Red maple,	1888	2
Acer spicatum,	Mountain maple,	1882	4
Acer saccharinum,	Sugar maple,	1878	7
Acer saccharinum,	Sugar maple,	1882	4
Acer pseudo-platanus,	Sycamore maple,	1882	8
Acer macrophyllum,	Large-leaved maple,	1882	6
Aesculus hypocastanum,	Horse chestnut,	1875	3
Aesculus hypocastanum,	Horse chestnut,	1882	1
Aesculus hypocastanum,	Horse chestnut,	1886	3
Aesculus florepleno,	Horse chestnut,	1875	1
Aesculus glabra,	Ohio buckeye,	1882	1
Aristolochia sipho,	Dutchman's pipe,	1882	1
Ampelopsis quinquefolia,	Virginia creeper,	1882	3
Ailanthus glandulosa,	Tree of heaven,	1860	2
Berberis Canadensis,	American berberry,	1875	2
Berberis aquifolia,	Mahonia,	1882	20
Betula populifolia,	American white birch,	1860	1
Betula populifolia,	American white birch,	1882	13
Betula papyracea,	Paper birch,	1882	2
Betula papyracea,	Paper birch,	1888	4
Catalpa speciosa,	Catalpa,	1882	4
Catalpa speciosa,	Catalpa,	1886	5
Carpinus Americana,	American hornbeam,	1887	2
Cercis Canadensis,	Judas tree or red bud,	1886	4
Calycanthus floridus,	Sweet-scented shrub,	1882	1
Cerasus Mahaleb,	Mahaleb cherry,	1875	1
Cerasus Virginiana,	Choke cherry,	Native.	3

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BOTANICAL NAME.	COMMON NAME.	Year of planting.	No. of plants.
Celastrus scandens,	Bitter sweet,	Native.	1
Clematis Virginiana,	Virgin's bower,	Native.	1
Cornus sanguinea,	Red dogwood,	1888	4
Cornus sanguinea var.,	Variegated dogwood,	1888	2
Carya amara,	Bitternut hickory,	1875	2
Celtis occidentalis,	American hackberry,	1875	1
Corylus Americana,	Hazelnut,	Native.	Cluster.
Euonymus radicans var.,		1882	1
Enonymus atropurpurea,	Spindle tree,	1882	3
Eulalia japonica var.,		1882	1
Forsythia viridissima,	Golden bell,	1875	14
Forsythia viridissima,	Golden bell,	1882	1
Fagus sylvaticus purpureus,	Purple beech,	1868	1
Fagus sylvaticus purpureus,	Purple beech,	1882	2
Fraxinus Americana,	American ash,	1875	2
Fraxinus Americana,	American ash,	1882	2
Fraxinus Americana,	American ash,	1885	16
Fraxinus Americana,	American ash,	1887	2
Gleditchia triacanthos,	Honey locust,	1875	1
Hibiscus Syriacus,	Rose of Sharon althaea,	1888	1
Hydrangea paniculata grandiflora,	Hardy hydrangea,	1882	2
Halesia tetraptera,	Snowdrop tree,	1875	1
Halesia tetraptera,	Snowdrop tree.	1887	1
Juniperus venusta,		1888	3
Juglans nigra,	American black walnut,	1882	7
Juglans nigra,	American black walnut,	1886	4
Juniperus Virginiana,	Red cedar,	1882	4
Juniperus Virginiana,	Red cedar,	1886	1
Lonicera tartarica,	Tartarian honeysuckle,	1872	4
Lonicera Halleana,	Hall's Japan honeysuckle,	1884	1
Liriodendron tulipifera,	Tulip tree,	1872	3
Liriodendron tulipifera,	Tulip tree,	1882	4
Liriodendron tulipifera,	Tulip tree,	1887	2
Liriodendron tulipifera,	Tulip tree,	1888	1
Larix Europea,	European larch,	1860	7
Larix Europea,	European larch,	1888	1
Magnolia tripetala,	Umbrella magnolia,	1888	4
Magnolia acuminata,	Cucumber tree,	1886	1
Magnolia purpurea,		1888	1
Nymphea odorata,	Fragrant white pond lily,	1882	10
Negundo aceroides,	Box elder,	1882	2
Negundo aceroides,	Box elder,	1887	2
Negundo aceroides,	Box elder,	1888	3
Pinus sylvestris,	Scotch pine,	1882	1
Pinus sylvestris,	Scotch pine,	1888	4
Pinus Austriaca,	Austrian pine,	1860	8
Pinus Austriaca,	Austrian pine,	1888	3
Pinus strobus,	White pine,	1860	4
Platanus occidentalis,	Sycamore,	1892	6
Pyrus japonica,	Japan quince,	1882	1
Populus dilatata,	Lombardy poplar,	1888	2
Populus grandidentata pendula,	Weeping poplar,	1888	1
Philadelphus coronarius,	Mock orange,	1875	3
Robinia pseudacacia,	Locust tree,	1860	2
Rubus occidentalis,	Black raspberry,	Native.	5
Spirea prunifolia flore-pleno,	Double-flowered spirea,	1882	1
Spirea crataegifolia,		1888	2
Spirea callosa,		1888	1
Syringa vulgaris albus,	White lilac,	1882	1
Salix Babylonica,	Weeping willow,	1859	1
Salix caprea pendula,	Kilmarnock willow,	1888	2
Typha latifolia,	Cat-tail flag (in pond),	1884	50
Thuja occidentalis,	American arbor vitae,	1875	4
Thuja occidentalis,	American arbor vitae,	1882	1
Tilia Americana,	American linden,	1860	2

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BOTONICAL NAME.	COMMON NAME.	Year of planting	No. of plants.
Tilia Americana, ...	American linden, . . .	1882	1
Tilia Americana, ...	American linden, . . .	1887	1
Ulmus campestris, ...	English elm, ...	1888	2
Ulmus Americana, . . .	American elm, ...	1859	1
Ulmus Americana, ...	American elm, . . .	1878	1
Vitis cordifolia, ...	Frost grape, ...	1878	1
Viburnum opulus sterilis,	Snow-ball tree, ...	1882	1
Weigelia rosea multiflora,	Weigelia, ...	1882	4
Weigelia rosea multiflora,	Weigelia, ...	1888	2
Weigelia variegata, ...	Var. weigelia, ...	1882	1
Weigelia rosea, ...	Weigelia, ...	1882	3
Wistaria sinensis, ...	. . . . .	1882	1
Yucca filamentosa, ...	Adam's needle, ...	1882	20

GEO. C. BUTZ.

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8. LADIES' DEPARTMENT.

GEORGE W. ATHERTON, LL.D., *President:*

SIR: For several years past there has seemed to be no occasion for a special report for the Ladies' Department of the College. Reports from the different departments of instruction covered the class work of the ladies; and other matters relating to this branch of the institution required no special mention, since the Trustees were known to be providing for its wants as fully as existing circumstances allowed. The increase of facilities in other directions, however, now encourages the hope that some much needed improvements in this department may receive favorable consideration.

The general policy of the institution being to undertake only what it can do thoroughly well—the question whether to increase the accommodations and facilities of the Ladies' Department, or abolish it altogether, should now be discussed. Thus far the thought has been not to advertise this department prominently, nor to offer special inducements to ladies to enter it, but simply to receive such as chose to avail themselves of the same opportunities as were offered young men. The institution being largely, if not strictly technical, was not likely, in the state of public opinion at the time of its opening to ladies in 1871, to draw a large number of young women. Consequently, for the first ten years very few entered with the purpose of taking a full four years' course. A considerably larger number entered the preparatory department, but were content with one or two years there, or even less. Up to 1884 but three ladies had been graduated from the full four years' course. In September, 1884, the course known as the "Ladies' Course in Literature and Science," covering two years' college work, went into operation. Since that time there have been three graduates in the full four years' course, and four in the two years' course. For two years past the special course has had no students, and the full courses a larger number than ever before—there being nine in 1886–7 and ten in 1887–8. Nine are now carrying full work. One in the "Natural History Course," three in the "General Science" and five in the "Latin Scientific Course." Another is teaching, at present, and taking certain subjects in the college with a view to resuming her place in the Sophomore class in the spring session; her purpose being to complete the course in "Advanced Chemistry." It is a gratifying fact that these students, with scarcely an exception, maintain a high standard of scholarship, some of them being among the first in their classes in the higher mathematics, as well as in literary work.

The whole number of ladies in the institution is not included in

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the foregoing statements. The number in the preparatory department, the present year, is fifteen, making a total of twenty-five, which has been about the average number of lady students for the last few years. The percentage of young women, therefore, to the whole body of students compares very favorably with the number in similar institutions such as "Cornell University," "The Illinois Industrial University," "Purdue University," etc. The facts mentioned are sufficient evidence that the maintenace of this department in the college has met a public demand. If so fairly satisfactory results have been obtained by admitting young women on sufferance, so to speak, it is reasonable to expect that the department might be made one of the most successful in the college, by the introduction of some much needed changes.

I am aware that the Trustees, as well as those more directly affected have felt the need of suitable quarters, ever since ladies were admitted. With the increase of male students the case has become more urgent. The department now occupies a small portion of the third and fourth floors of the main building. There is no opportunity for furnishing board to the young ladies in these quarters, and it is impossible to secure a suitable permanent boarding place in a private family. A very satisfactory arrangement has been made for the remainder of the present year, by which all are accommodated at a private table in the building. But even if the same rooms on the second floor could be secured for another year, it is not at all probable that the present arrangement could be continued, the circumstances being such as to make the work of providing for a large family very difficult. The old system by which such as preferred to do so were allowed to board themselves has been this year discontinued. The college could not well afford longer to give the necessary room for kitchen and dining room, and the general effect on the health of those who availed themselves of the privilege was believed to be injurious, to say nothing of the discomforts to which others were thereby subjected. The question of board alone will, therefore, be a very perplexing one at the opening of another year. That the ladies should be expected to find separate places in the village, wherever possible, as is now done by the gentlemen is not to be thought of, and it is generally admitted that a refined family life plays no small part in the liberal education of young women. A building to accommodate forty persons, if the same proportion as heretofore continue to reside with friends in the neighborhood, would be entirely adequate to the demand, for the next few years. Such a building, if properly constructed, could be used for other purposes should it seem inadvisable, at the end of a fair trial, to continue the department separately.

Next in importance to suitable quarters is the need of certain new lines of training for the ladies, in place of some of the present practicums. An option has heretofore been allowed in the Mechanic Arts

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and Surveying, the only possible substitute being music. This substitution has been, in nearly all cases, very unsatisfactory; for the rea son that not all young women have a taste for that art, and the mere substitution gives no opportunity for the systematic study of music. This will be understood from the fact that the election is possible for only six hours per week, in the winter session of the freshman year; for four and two hours per week, in the fall and winter sessions, respectively, of the Sophomore year. The total number of hours possible for the study of music, in connection with a full College course, is therefore inadequate for even an elementary knowledge of that branch, and is likly to give the student the impression that it is a mere makeshift, to fill up the required number of working hours. It is understood that music constitutes no part of any College course of studies, and facilities for instruction and provided only to meet the wants of such as especially desire to study music in addition to their regular work. It is doubtful whether it would be well to change this policy, and introduce the study of music into any course leading up to a scientific degree. The subject is not one which meets the needs of all students, and many cannot afford the additional expense.

The present extended work in Mechanical Drawing, also, has not the same practical utility for the ladies that it has for the young men, and, though one of the practicums required of all, it has thus far failed to commend itself as a wise expenditure of time and effort for young women in general. The establishment of a systematic course in Industrial Art, including, of course, extensive training in free-hand drawing, to take the place of the subjects mentioned, would be of great practical value to all. Industrial drawing and designing as applied to modeling, wood-carving, designs for wall paper, carpets, house decoration, and fabrics of all kinds opens to young women a wide and attractive field of useful employment, and gives the training of the hand and eye now so generally recognized as a stimulus and aid to purely intellectual training. The striking results attained by young women taking similar work in other institutions, would be a sufficient reason for a careful consideration of the feasibility of introducing such a course here, without the more urgent reason that there exists, at present, nothing to compensate for the lack of it. Without going into details, it is perhaps sufficient to say here that, if an instructor could be provided, there would be no difficulty in the way of establishing the course at once.

Should a separate building be provided, a course in "Domestic Economy" should also be established for young women. This does not mean simply a "Cooking School," but instruction in the chemistry of foods, scientific principles of hygiene and dietetics, the preparation of foods "for the nourishment instead of the destruction of the body" with practice in the kitchen, as a laboratory. Such instruction could be provided at little additional expense, if the necessary quarters

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were available. The healthy tone in regard to household matters resulting from this kind of training has been found to be of as great importance to young ladies, as the knowledge acquired, and it goes far toward overcoming any tendency in the higher education to unfit them for the plain duties which crowd the daily life of most women, and are apt to be underestimated in comparison with the more ornamental.

The above are the most urgent needs of this department, and should be met at no distant day. If provision cannot be made for all of them, at the present time, it is earnestly recommended that at least an instructor in industrial drawing and designing be employed to enter upon duty at the opening of another year.

Respectfully submitted.

HARRIET A. MCELWAIN.

STATE COLLEGE, PA., *Janary, 19, 1889.*

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9. LIBRARY.

December 31, 1888.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: I have the honor to submit the following report of the College Library for the year 1887.

During the year the library has received, in addition to the regular subscription list, 215 bound volumes, by purchase and donation; 477 sheep bound volumes of public documents, as the first instalment of public documents received on account of this institution having been designated as a depository of public documents; and about seventy-five pamphlets of various kinds.

The library, by means of the one hundred dollars appropriated for assistants, has been open about six hours per day, except for a few weeks at the beginning of the fall term, when changes in progress in the college building made it impossible for the library to be freely accessible for a time. By the aid of this appropriation, the library has been much more useful to all connected with the college and I am encouraged to ask that a further step, in this direction, be made by increasing this appropriation for library service. For one hundred and sixty dollars, I think, the library can be kept open during all the working hours of the day, and for two hundred dollars, during the day and evening.

There is an increased demand for technical periodicals which the regular appropriation has not been able to supply. I therefore ask for an increase of appropriation for such purposes for 1889.

At least five new book cases are needed at once, and, as soon as the State appropriation becomes available, the need for several more will be imperative. No books or periodicals can now be kept under lock and key as is sometimes desirable.

The space to be occupied by the library will soon be insufficient for its growth and convenience, so that in changes in arrangement of space, additional room should be secured for library purposes. If possible, the reading room should be entirely separated from the library proper, and there should be a storage room for duplicates and library materials not in use.

Governor Beaver has suggested the establishment of a section in the library for a collection of works on the history of our State. I think that we can make a good beginning in that direction and have no doubt that we may receive a good deal of help from friends of the

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college. To make it a success there ought to be some funds at the disposal of the librarian for the purchase of works, which cannot otherwise be obtained. Hon. John B. Linn has already presented us with several valuable books and pamphlets on local history.

Respectfully submitted.

CHARLES F. REEVES, *Librarian.*

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10. MATHEMATICS.

GEO. W. ATHERTON, LL. D., *President:*

SIR: The Freshman class has been steadily increasing in numbers for several years past, until it is now too large to be instructed satisfactorily in one section. It is true that in some institutions larger classes are occasionally under the charge of a Professor, but in such cases the students are more uniformly prepared when they enter, and need little individual or special attention. Comparatively few of the preparatory training schools are feeders to this institution (although there is a gradual improvement in this respect), consequently many of our Freshmen have been very irregularly prepared for college work. Among such, however, is a proportion of young men who have not had school opportunities in early life, and being desirous of having a college education, cannot afford the time and expense to prepare themselves to meet the full requirements of college admission. These young men, generally, have the zeal and industry to make good their deficiencies during their college course, if they can be given some special assistance. To do this usually requires the formation of extra classes, and in the past some of the professors of technical departments have volunteered to meet this additional labor, but at the present time the growing interest in, and popularity of these departments require their entire attention. This extra labor must, therefore, fall on the Professor of mathematics, and added to his regular work is somewhat burdensome. But such work must be done for some years to come, if you would maintain the increasing prosperity of the institution and prevent the classes from dwindling very much in membership, before the Junior and Senior years are reached. Many of the students who come into the College from our Preparatory Department need much special assistance, and this must continue to be so, while we attempt to press into two years, the preparation that takes four years in some of the best training schools of the country, with the same grade and class of pupils. An urgent reason for dividing the Freshman and Sophomore classes into two sections is, that the students who are preparing for any of the engineering courses require more mathematics than those of the other courses, hence all should not be taught together. But such a division would double the number of classes in the Freshman and Sophomore years and, consequently, add to the labor of the Professor to this extent, which has recently been increased by the addition to the list of pure mathematics of determinants, differential equations and quaternions. But this work might be carried, for a time at least, without an assistant, if you could see your way clear to employ a trained elocutionist to take charge of the rhetorical and essay work of the

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college. At present this is poorly provided for, and the insufficiency becomes more and more apparent as the number of students increases. This is clearly shown by the fact that at present but half an hour per term can be devoted to each student in rhetorical training. This institution has no more imperative need than better opportunities for such instruction. In the effort to make the technical departments strong and capable of competing with those of other institutions, there is danger of overlooking the general culture (including rhetorical and essay work) which is essential in all the callings of life. I would suggest a slight change in the order of mathematical subjects, *i. e.*, that higher algebra, which is now placed in the first term of the Freshman year, should succeed plane and solid geometry and trigonometry. The higher algebra involves a number of abstract conceptions, such as functions, limits, series, the general theory of equations, etc., which the beginner finds very difficult to grasp. One or two terms of college training in easier subjects would prepare him to grapple with those which are more difficult.

Respectfully submitted.

J. JACKSON,
Professor of Mathematics.

STATE COLLEGE, PA., *January 17, 1889.*

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11. MECHANICAL ENGINEERING AND MECHANIC ARTS.

Mechanical Engineering Department.

1. Work of the Department.

George W. Atherton, LL. D., *President:*

Sir; I have the honor to submit the following report of the Departments of Mechanical Engineering and Mechanic Arts.

During the year 1888, the instruction given in the Mechanical Engineering Course is as indicated in the catalogue, with the exception of the mechanical drawing, of which I will speak later, and some additional work done in the department of pure mathematics.

The technical instruction of this course, with the exception of the practicum, opens in the spring session of the Sophomore year, when the subject of *mechanics of machinery* is taken up. Not only students in mechanical engineering but those in civil engineering and electrotechnics are required to take this study. The mechanical engineers continue the study through the first term of their Junior year, students in other courses being required to take it during but one term. A thesis on the subject of "Governors" was required in connection with this study.

During the winter term of the Junior year the members of the Mechanical Engineering Course were engaged in the study of *materials of engineering*, and, at the same time, that of *valve gearing*. In the latter branch in addition to careful text-book work, attention was given to original designing, and a study of *valves*, as found in actual practice upon various steam engines, a practical acquaintance with this work being of vital importance to a steam engineer.

The subject of materials of engineering has been pursued under unfavorable conditions, on account of the need for testing machines. It is my purpose in connection with this study to carry on experimental work with the various materials as they are treated of in the next text. By this method not only corroborating the results obtained by experience and practice of others, but at the same time teaching the student how he may test for himself at any time the quality and capacity for endurance of any engineering material. When it is remembered how numerous are the materials of engineering, and under what different conditions they may exist (as to purity, etc.) the importance of actual tests may be readily appreciated and the impossibility of finding exact data in tables may, to some extent, be realized. Machines for making such tests are about to be purchased.

During the following term the subject of *thermo-dynamics* was

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treated. Here, in addition to a thorough study of the laws of heat, the following subjects were discussed both experimentally, and in lectures: the conditions under which combustion takes place; the amount of air necessary to the complete combustion of different grades of coal; determination of the quality of fuel; the form of chimneys; the advantages and disadvantages of superheated steam; the use of condensers; feed water heaters, etc., etc.

A study of the *graphical statics of machinery*, followed by a course of lectures on *Lubricants* was an important part of the term's work. In the former branch the efficiency of machines is determined by graphical methods, as well as the amount of power dissipated in overcoming the friction in the machine itself. The efficiency of a number of the machines in our shop was calculated by this method, and the results compared with those taken by the steam engine indicator.

In lecturing on the subject of Lubricants, attention was given to the kinds of Lubricants; the composition of the various kinds; the varying efficiency of each under different conditions of material; and the question of the effects produced by pressure, velocity, temperature, etc. Having fully considered the materials of his machine, and the conditions of its running, the engineer is enabled to select the lubricant best suited to his purposes.

The laboratory work in connection with this subject will consist in the determination of the coefficients of friction between materials used in machine construction, different oils being used, and observations taken under the varying conditions of pressure, velocity, temperature, etc. The importance of including this subject in the education of a Mechanical Engineer has but recently been recognized. Theoretical and practical observations have led to surprising results.

It has been estimated that a change of oil used in some of our large manufacturing establishments would save fully $5,000 annually, by reducing the power necessary to perform the work to a minimum, as well as by diminishing wear and tear of bearings, the former, however, being the item of greatest importance. A machine has been ordered for the purpose of testing the efficiency of oils under all the circumstances mentioned.

At the same time the study of the *Indicator* was taken up. Here also actual experiments were made in connection with the text. Tests were made upon our electric light engine with reference to the quantity of coal consumed per horse power developed by the engine, and as to how this quantity is affected by a varying load upon the engine. The load was varied by attaching and detaching different machines, and also by the use of a Proney brake.

Further experimental work was done with the automatic governor, noting the effect produced upon the efficiency of the engine (as to regulation, etc.), by changing the cut-off.

By means of the *Tabor Indicator* the power necessary to run different

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machines in the shop was calculated, both when working and when not working. In this way the number of horse power required to perform various given kinds of work was determined; also how the power is affected by the speed of the driven machine, and how it is affected by depth of cut in such machines as planes and lathes. It is our purpose to go still further into this work, and show how gearing, and arrangement of belting and shafting will affect the power. Having first made the requisite calculations theoretically, we will, by actual experiment, reduce the power required to do a given work to a minimum, and thus arrive at the most economical arrangement.

Work is also being done with injectors and pumps in order to ascertain the most economical way of feeding the boiler, this reducing itself essentially to the determination of the quantity of coal consumed per horse power of work accomplished by the engine.

Schaeffer and Buddenburg, of New York city, have presented us with an exhaust steam injector. This is being put up at the present time. When ready for use it is proposed to have the Mechanical Engineers of the Senior class apply tests in order to ascertain the economy, if any, in its use.

Mr. Cooper, superintendent of the electric light plant in Bellefonte, has kindly given me permission to take my classes to his station with the object of testing the efficiency of the engines in use there. This I shall do.

It is eminently desirable that the Senior class should take a much more extended trip for the purpose of observing the arrangement and equipment of large shops, peculiar combinations of mechanisms and methods of work. A trip to Pittsburgh for this purpose would be of the greatest possible value to the advanced students in Mechanical Engineering, but if so extended a trip were impracticable, arrangements should be made by which the shops in Altoona could be visited. No doubt Mr. Stratton, Superintendent of the Pennsylvania railroad shops, who has rendered me kindly services in the past, would accord his permission to an inspection of his shops. The need of an appropriation to aid in paying the expenses incurred such trips is quite obvious, not only from the fact that many of the students would find it impossible to meet the necessary expenditure, but that there may be those who would fail to see the full advantage to be gained from such an experience. That the advantage to be derived would be great need not be urged to you. Following a course in theoretical work, in conjunction with that which is practical, done in our home shops and laboratories, a close, intelligent observation of extensive shops arranged, equipped and conducted in the best possible manner, cannot but be of lasting value.

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Mechanical Drawing.

During the winter and spring sessions of 1888, forty-eight students received instruction in mechanical drawing, but owing to the changes being made in that wing of the building in which the drawing rooms are situated, it has been impossible to give instruction in drawing during the term just past. Consequently the time allotted to drawing was given to shop work with the understanding that drawing should be substituted for shop work during the two sessions following.

As the elementary mechanical drawing includes the whole number of students in the freshman class it requires from the instructor much time and care, during part of the year filling every afternoon in the week. At present this drawing is under my direct care. This is unfortunate as my time and attention should be given to the advanced Mechanical Engineering students, whose work being largely of an experimental nature requires special preparation in the way of appliances, and direct supervision. This in addition to my oversight of the work in the Mechanic Arts department leaves me but little time for the elementary drawing, and it is impossible for me to give to it the attention and care necessary to bring about the best results. Although to many of the students who take it, this drawing is merely a general training without reference to preparation for a technical course, yet it is desirable that the work should be so laid out as to best prepare the technical students for subsequent work, since this may be done without detriment to those pursuing other courses. If a special instructor be procured, I would suggest that it might be well to have his work under the general supervision of one of the engineering departments.

In this connection I would urgently recommend that the free-hand drawing of the Preparatory Department be put in charge of a competent instructor, whose object it would be to give the work sufficient time and attention to bring about good results in preparation for the advanced work. Rapidity and neatness in free-hand drawing are essentials to success in mechanical drawing, or any engineering work. Our students hitherto have not had suffcient drill in free-hand drawing in their preparatory course

The Electric Light Plant

The supervision of which is under my care, has, I believe, given entire satisfaction during the year. We have re-wired the central part of the main building, and are at present wiring the rear central wing.

In a test made by the Mechanical Engineering students, under my direction, it was determined that at no time are more than thirty-one horse power required to run our dynamo. Indicator cards were taken from both ends of the cylinder of the engine every half hour, from two in the afternoon until eleven at night. The power was calculated from these cards and it was found to range from twenty to thirty-one

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horse power, depending upon the number of lights turned on. The engine has a capacity of fifty horse power, and could be run to this power with but slight additional cost. Consequently if a sufficient number of lights were added to require the additional power, from which the ordinary financial return might be realized, it would be a matter of economy.

Mechanic Arts Department.

The number of students who have received instruction in the shop during the past year is 101. As there are but twelve benches in the carpenter shop, and the members of the Freshman class of this year taking this work number thirty, it was necessary either to divide the class into three sections, or to put part of the class at wood-turning before having had the carpentry. The former course was impracticable on account of interference with class-room work and other practicums. It was, therefore, necessary to adopt the second course. This has been far from satisfactory, as that part of the class which had wood-turning first took up carpentry with less interest and enthusiasm than those who began their shop work with the latter branch. Besides this it is almost impossible to make up a schedule of the work. That which has been said of the carpentry shop is true of the other rooms, the numbers here, however, not being so great, as students in technical courses only are required to take the work.

I do not wish to be understood to say that we have not reached good results in our work during the past year. The work has been better than that of any previous year, but to reach the best results the shops should be increased to at least twice their present capacity.

As the interest in industrial education, or manual training, grows, we are more and more frequently called upon to give information concerning our work. We have sent out during the past few months, blue prints and models of our work to a large number of institutions, also copies of my report for 1886. I, therefore, annex hereto floor plans of our building, and plates with explanations of our course, among which are included plates not given in the report for 1886. I have also here indicated a few changes made in the course as experience has shown a need for them. The cut of a steam engine which I append is from a photograph taken from an engine made by students in the department, the drawings and entire work having been performed by them.

Buildings, Etc.

Our building is a two-story frame, fifty by thirty-four feet, with a wing for machinery and lumber, recently added, thirty by eighteen feet. The main part is divided into four compartments, viz: Carpenter shop, wood-turning room, forge room and machine shop. One story of the wing is used for lumber, the other for the wood planer. The floor plans more fully show the form of the building and the arrangement of the machines.

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Carpentry and Joinery.

In the carpenter shop we have at present three benches twelve feet long and four and a half feet wide. Each bench is provided with four sets of tools, four vises, and with each vise two drawers and two cupboards under the tables. Each set of tools is composed of the following: One jack plane, one jointer, one smooth plane, one cross-cut saw, one rip saw, one back saw, one set of eight firmer chisels, one set of six framing chisels, one drawing knife, one bit brace, one set of eleven Pugh's bits, one mallet, one hatchet, one oil stone, one try square, one bevel, one mortise gauge, one scratch guage, one two-foot rule and one nail set.

There are also a number of special tools which the students are given as they need them, such as matching planes, filletster planes, hollowing and rounding planes, a set of iron planes, beading planes, clamps, etc.

Every student is taught how to prepare blue prints of the pieces he is to make, all the work being done from blue prints. At the same time an instructor is present to assist when necessary. The student is not permitted to leave any piece until he has made it to the satisfaction of the instructor.

The schedules of the courses in Mechanic Arts and Mechanical Engineering are here given, in order to show more fully the character of the theoretical instruction and the distribution of the practical work.

In the course in Mechanic Arts special prominence is given to manual education, it being intended for those who wish to enter upon industrial pursuits rather than to become scientific engineers. It is designed to afford such students as have had the ordinary common-school education an opportunity to continue the elementary scientific and literary studies, together with mechanical and free-hand drawing, while receiving theoretical and practical instruction in the various mechanical arts.

The number of hours given to shop-work is not large, but it must be remembered that the students are under the eye of a competent mechanic whose sole object is to give instruction, and the work which has been produced from these shops shows what may be accomplished in so short a time under this system.

MECHANIC ARTS.

[Figures indicate hours per week.]

First Year.

FALL SESSION.—United States History (3), Arithmetic (4), English Grammar (5).

Practicum.—Carpentry (4), Geometrical Free-hand Drawing (5).

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WINTER SESSION.—Algebra (5), English Composition (5), United States History (3).

Practicum.—Carpentry and Joining (6), Model and Object Drawing (5).

SPRING SESSION.—Algebra (5), English Composition (5), Book-keeping (4).

Practicum.—Wood-turning (6), Designing (4).

Second Year.

FALL SESSION.—Geometry (2), Algebra (4), Physics (4).

Practicum.—Patternmaking (6), Geometrical Drawing (6).

WINTER SESSION.—Geometry (2), Algebra (4), Physics, (4).

Practicum.—Foundry Work (6), Orthographic Projection and Intersections (5).

SPRING SESSION.—Geometry (4), Algebra (5), Mechanics (3), Civil Government (2).

Practicum.—Forging (8), Developing of Surfaces, etc. (6).

Third Year.

FALL SESSION.—Algebra (4), Geometry, (2), Mechanics (4).

Practicum.—Forging (6), Linear Perspective and Shades and Shadows (9).

WINTER SESSION.—Geometry (3), Trigonometry (3), Rhetoric (4).

Practicum.—Vise Work (6), Detail Drawing (9).

SPRING SESSION.—Trigonometry and Surveying (5), Mechanism (5).

Practicum.—Machine Tool Work, Machine Designing (9).

It will be seen that in the Mechanical Engineering course the shop-work is very similar to that required of the students in the elementary course. There is, however, this difference: In the last year of the advanced course, the shop-work is almost entirely machine construction of the student's own designing. Besides this, testing the strength of materials and experimental work with boilers, inspirators, governors, indicators, etc., is a prominent feature of their work.

MECHANICAL ENGINEERING.

Freshman Class.

FALL SESSION.—Algebra, *Newcomb's College* (4), Geometry, *Wentworth's Plane and Solid* (2), German, *Principia* (5), History, *Freeman's General Sketch* (4).

Practicum.—Drawing, Geometrical and Projection (4), Carpentry (4).

WINTER SESSION.—Trigonometry, *Olneys's Plane and Spherical* (3), Geometry, *Wentworth's Plane and Solid* (3), Rhetoric, *Welsh's* (4), German, *Principia and Wilhelm Tell* (5).

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Practicum.—Drawing, Intersections (2), Carpentry (6).

SPRING SESSION.—Trigonometry, *Olney's Plane and Spherical* (5), Physiology, *Martin's Human Body, Briefer Course* (3); German, *Wilhelm Tell* and *Minna Von Barnhelm* (5); Tactics (2).

Practicim—Drawing, Intersections and Developments (4); Wood-turning (4).

Sophomore Class.

FALL SESSION.—Analytic Geometry, *Bowser's* (5); Chemistry, *Harris' Lecture Notes on the Non Metals* (4); German, Historical *Selections* (2); French, *Principia* (3); Surveying, *Bellows and Hodgman* (1).

Practicum.—Surveying (4); Chemistry (4).

WINTER SESSION.—Analytic Geometry, *Bowser's* (3); Chemistry, *Harris' Qual. Analysis* (3); German, *Hodges' Scientific* (2); French, *Principia* (3); History, *Freeman's General Sketch* (4).

Practicum.—Chemistry, (8); Patternmaking (4).

SPRING SESSION.—French, *Racine's Athalie* and *Saintsbury's French Literature* (3); Differential Calculus, *Bowser's* (4); Descriptive Geometry, *Warren's* (4); Mechanics of Machinery, *Kennedy's* (5).

Practicum.—Mechanism (6); Drawing, Descriptive Geometry (4).

Junior Class.

FALL SESSION.—Physics, Mechanics and Heat, *Anthony and Brackett's* (4); Descriptive Geometry, Maps, Shades, Shadows, etc., *Warren's*, (4); Integral Calculus, *Bowser's* (3); Mechanics of Machinery, *Kennedy's* (4).

Practicum.—Dynamics (4); Mechanical Drawing (4).

WINTER SESSION.—Analytical and Graphical Statics, *Church's* (4); Physics, Electricity, *Anthony and Brackett's* (4); Materials of Construction, *Thurston's* (3); Determinants, *Peck's* (2); Valve Gearing, *Zeuner's* (2).

Practicum.—Physics (4); Forging (6).

SPRING SESSION.—Kinetics and Kinematics, *Church's* (4); Quarternions, *Hardy's* (4); Materials of Construction, *Thurston's* (3); Physics (4).

Practicum.—Chipping and Filing (6); Mineralogy (4).

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Senior Class.

FALL SESSION.—Thermo-dynamics, *Lectures* (3); Statics of Machinery and Lubricants (4); Geology, *Dana's*, (4); Political Economy, *Walker's* (4).

Practicum.—Mechanical Drawing (6); Engine Lathe Work (6).

WINTER SESSION.—Machine design, *Unwin's* (3); Steam and Steam Engines, *Weisbachs* and *Rankine's* (4); Experimental Work with Indicators, Injectors and Governors (2); Constitutional Law, *Cooley's* (4); Astronomy, *Newcomb* and *Holden's* (3).

Practicum.—Mechanical Drawing (4); Machine Construction and Testing Strength of Materials (6).

SPRING SESSION.—Machine Design, *Unwin's* (5); Electrical Machinery (3); Hydraulic Motors, *Lectures* (3); International Law, *Woolsey's* (4).

Practicum.—Machine Construction (4); Thesis Work (6).

(2) Financial Statement.

I herewith annex a supplementary report containing a financial statement of the Mechanic Arts Department.

Appropriation,			$500 00
Products from labor and material,			1,162 26
Fees from students,			136 50
Appropriation,			164 03
To balance,		$143 10	
Inventory (lumber, etc., in stock),		535 35	
Jas. Harris & Co. (hardware for job work),	$32 21		
Jas. Harris & Co. (hardware for job work),	2 84		
Jas. Harris & Co. (hardware for job work),	1 73		
		36 78	
J. K. McFarlane (iron and other hardware),	$18 89		
J. K. McFarlane (iron and other hardware),	18 21		
J. K. McFarlane (iron and other hardware),	7 85		
		44 95	
Getz & Tressler (repairing spouting),		3 00	
Logan Machine Works, steam fittings	$39 67		
Logan Machine Works, for drying coil,	4 40		
		44 07	
T. S. Bailey,	$0 35		
T. S. Bailey,	50		
		85	

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Jas. Hunter & Co. (pulleys),		$29 70	
Bill heads,		2 25	
College (steam fittings),	$7 48		
College (steam fittings),	1 65		
College (steam fittings),	20		
College (steam fittings),	20		
College (steam fittings),	25		
College (coal oil),	36		
College (coal oil),	42		
College (hauling machinery),	1 00		
		11 56	
Goodenow & Whiteman, castings for	$11 35		
Goodenow & Whiteman, work by students,	3 87		
		15 22	
Keuffel & Esser (blue print paper),	$4 05		
Keuffel & Esser (blue print paper),	4 80		
Keuffel & Esser (blue print paper),	3 56		
		12 41	
W. L. Foster (soap, nails, screws, etc.),		36 66	
Back charge (S. S. Pague),		3 60	
M. D. Snyder,	$2 58		
M. D. Snyder,	42		
		3 00	
W. P. Duncan (small castings for students' work),		16 80	
Hauling lumber (college),	$29 00		
Ash lumber (W. J. Thompson),	16 99		
Yellow pine,	390 37		
Lumber,	9 40		
Lumber (P. B. Crider & Sons),	23 54		
		469 30	
Freight paid during year,		12 53	
Salary and wages for year,		1,349 97	
Stock on hand,			$512 00
		2,771 10	2,474 79
By balance,			$296 31

As my account shows, the income of this department during the year past has been, by appropriation, $664.03; by fees from students, $136.50; by products, $1,162.26. From the last item $450.00 must be subtracted, as that sum was paid for lumber in the rough which was turned out and sold in the shape of flooring, wainscoting, etc. We have, then, a total income of $1,512.79 for the year 1888. During the year 1887, the income was, by appropriation, $1,400.00; by fees from students, nothing; by products, $405.23, making a total of $1,800.23. Although there s been a considerable increase in the income from products this year, vill be seen that this advance, even with the fees received from

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students in addition to it, is not sufficient by $292.44 to make up for the large falling off in appropriation. This deficiency has been the more seriously felt for the reason that the greatest item of expenditure in my department, that of wages to be paid, has been larger this year than ever before, for the following reasons:

1st. Two months of the engineer's salary was charged to my department, whereas in the past this has not been done.

2d. On account of the greater demand for water, it was frequently found necessary to run the pump both night and day, thus necessitating the employment of an extra hand.

3d. It was occasionally necessary to employ extra hands in order to do the job work taken in. By job work I mean work done for outside departments, or individuals, therefore being a source of income.

There has been an increase in the amount of job work done, as is indicated by the income derived from it, yet, under the present conditions, the shop cannot be to any degree self-supporting. This may be seen clearly from the following statements:

1st. A large part of the income derived from job work during this year was from lumber taken in the rough, and turned out in the shape of flooring, wainscoting, etc. That we were able to obtain this lumber at so low a figure and afterwards find purchasers for it, were largely matters of chance, and a recurrence of such a condition of things cannot be depended upon.

2d. The salary of one man, employed at $384.00 per year, brings absolutely no return in the form of income, as his full time is required to do the pumping and janitor work of the shop. The salary of the engineer, of which $154.00 was this year paid by my department, brings little financial return, as his time is almost exclusively devoted to the students and the electric light plant, exceptionally so during the past year, on account of new wiring, and repairs done, in the college building. The service of the carpenter at $540.00 per year, is a source of income, greater or less, according to the number of students under his charge. During the past year this number has been so much in excess of the accommodations provided in the wood-working rooms, that the carpenter has been obliged to give from 8.00 until 12.00 o'clock in the morning, and from 1.00 until 4.00 in the afternoon, in order to accomplish the work scheduled for the different courses. If the shops were enlarged to double their present capacity it would not be necessary to put classes in the shops during the entire day, and both the engineer and carpenter could then devote more time to job work.

However, these being the conditions, unless a sufficient appropriation be made, the account will of necessity be overdrawn, as is the case this year. A much larger sum must have been overdrawn had it not been for the unusual advantage we had in getting the lumber already mentioned at a very low price, and being enabled to dispose of it in the finished condition profitably.

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At the beginning of the year when $500.00 was appropriated to my department, I was given to understand that this was not considered sufficient, and that a further and adequate appropriation would be made. Under these circumstances the shop was conducted during the first half year on a basis as economical as advisable to secure the best conditions. There then being no further appropriation, the expenses were reduced to an absolute minimum amounting practically to nothing but wages paid. The $164.03 finally added to the first appropriation was insufficient to meet the demands.

In consideration of all these facts I would respectfully recommend that, in the appropriation for next year, the following items of expenditure be provided for:

For coal	$150 00
One-half the salary of pumpman and janitor,	192 00
Carpenter's salary	540 00
Three months of engineer's salary	231 00
Making a total of	$1,113 00

to meet next year's needs. To this, $296.31 should be added to make up the amount overdrawn in 1888.

During the past year no charge was made to my department for coal. I have estimated that about sixty tons of coal might be properly charged to the department which, at the present rates, can be purchased for $150.00.

I have included but one-half of the salary of pumpman and janitor because as fully one-half his time is given to pumping it might be advisable to charge that fraction of his pay to the water supply account.

With an appropriation of $1,400.00 to meet the needs above mentioned, I believe it quite possible for the general running of the shops to be carried on upon the income from job work, and the small amount received from the students as fees. Unless the number of students in shopwork decreases, thus relieving the carpenter of part of his work of instruction, more than this can scarcely be done.

If it were not for the need for economy I should strongly urge that there be no job work done in the shop during term time, as I am confident that the work of the students is more or less impaired by it. Furthermore, the carpenter must make a careful count of the tools used by the students after every class, and take note of the condition in which they are left. As things now are, with the rush of job work and large and frequent classes, it is practically impossible for him to give sufficient attention to this matter.

Respectfully submitted.

LOUIS E. REBER,
Professor of Mechanical Engineering.

STATE COLLEGE, PA., *January 20, 1889.*

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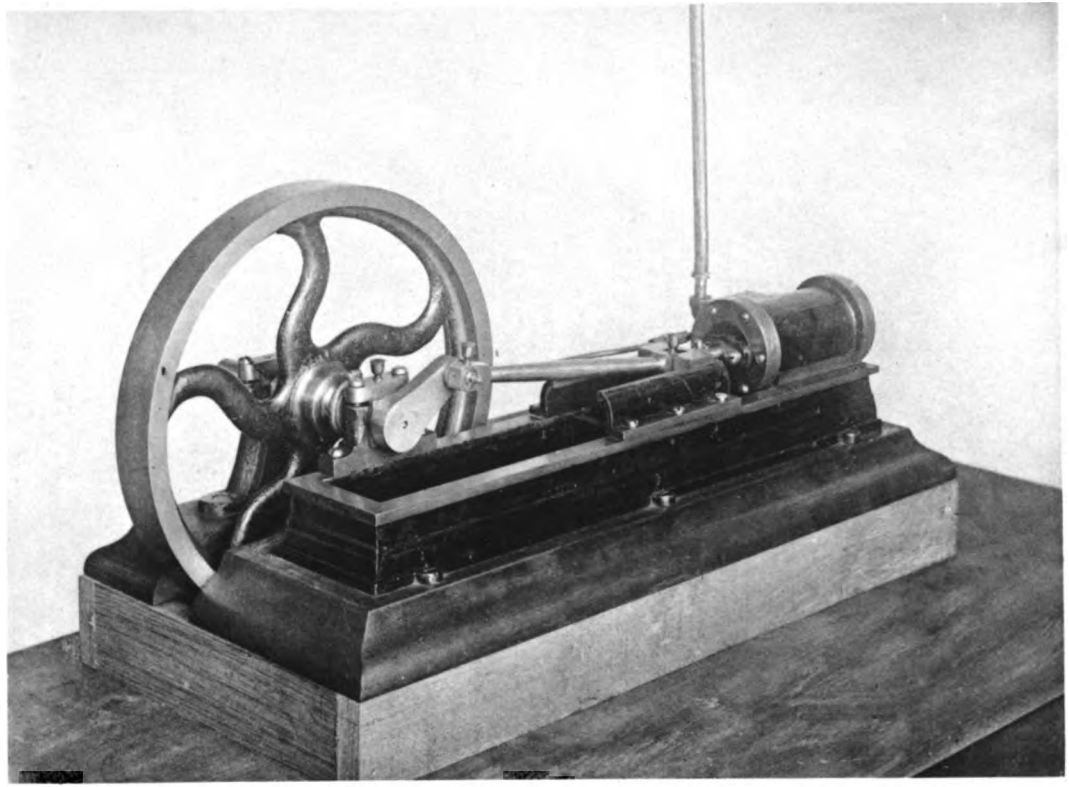

HORIZONTAL ENGINE.

Working Model made entirely by Students of the Pennsylvania State College.

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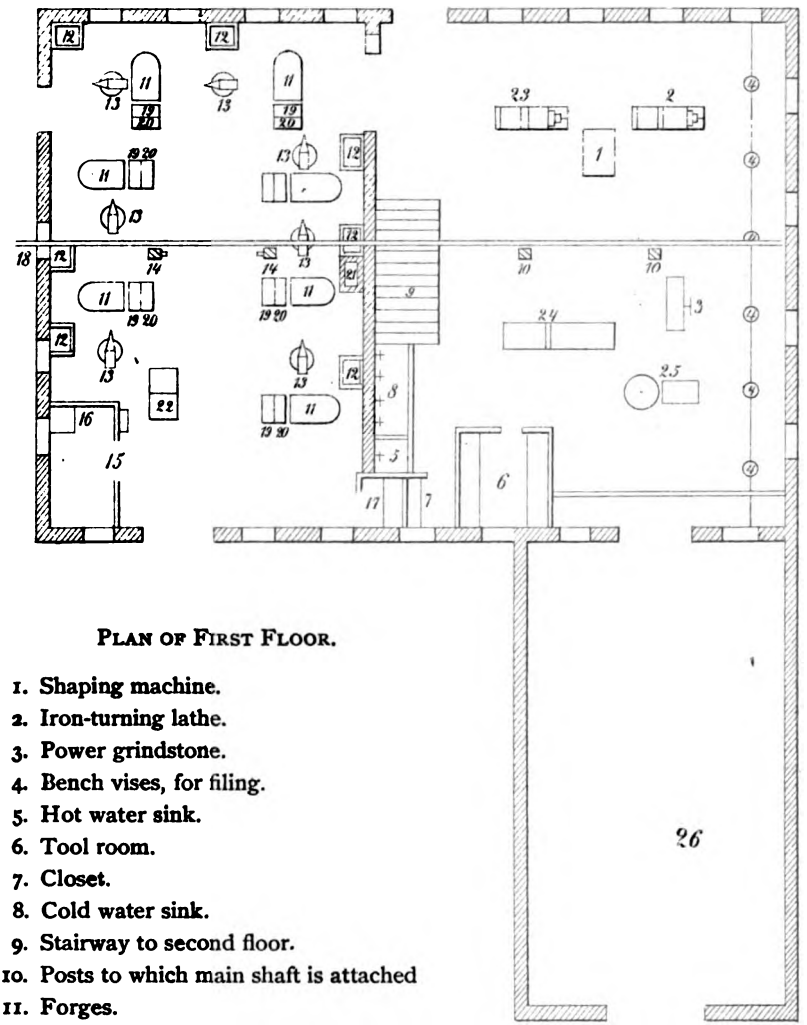

PLAN OF FIRST FLOOR.

1. Shaping machine.
2. Iron-turning lathe.
3. Power grindstone.
4. Bench vises, for filing.
5. Hot water sink.
6. Tool room.
7. Closet.
8. Cold water sink.
9. Stairway to second floor.
10. Posts to which main shaft is attached
11. Forges.
12. Stands for tools and work.
13. Anvils.
14. Large vises attached to post.
15. Iron room.
16. Steel pressure blower.
17. Closet.
18. Main shaft.
19. Coal tanks for forges.
20. Water tanks.
21. Chimney.
22. Box shear.
23. 16-inch P. & W. lathes, turret head.
24. 5-inch Sellers' planer.
25. Sellers' drill press.
26. Lumber room.

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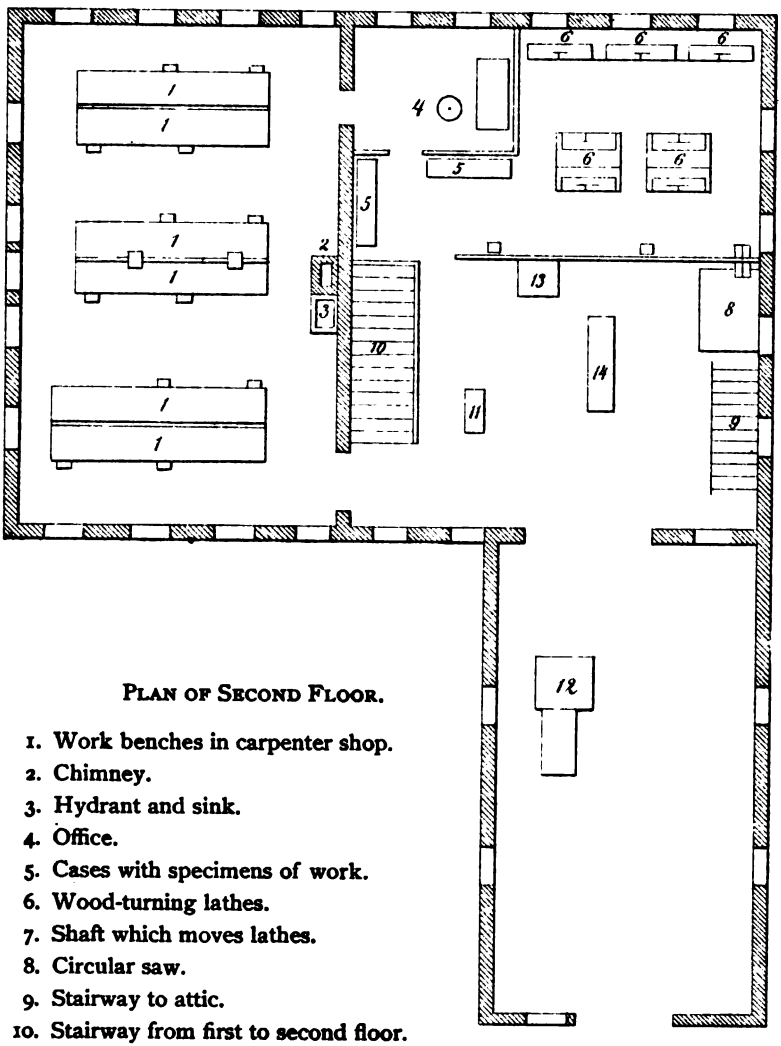

PLAN OF SECOND FLOOR.

1. Work benches in carpenter shop.
2. Chimney.
3. Hydrant and sink.
4. Office.
5. Cases with specimens of work.
6. Wood-turning lathes.
7. Shaft which moves lathes.
8. Circular saw.
9. Stairway to attic.
10. Stairway from first to second floor.
11. Grindstone.
12. Wood planer.
13. Scroll saw.
14. Universal woodworker.

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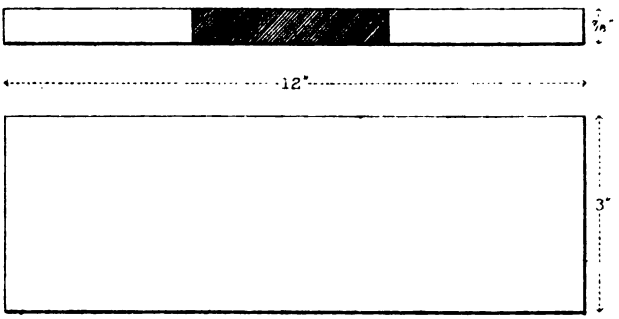
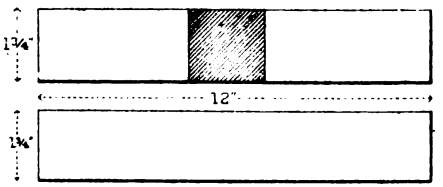
FIRST LESSON.



PLANING.

The student is given a rough one-inch pine board from which he is to saw a piece 12 inches long and 4 inches wide. The difference between a ripping- and cross-cutting saw is here explained to him. He planes one side smooth, using the proper planes, and from this face the edges and other side are worked, making the edges at right angles and face parallel to the working face. No effort is made in this exercise to work to dimensions.

SECOND LESSON.



PLANING SQUARE PRISM.

In this exercise, the material is 14 inches long and 2 inches square section. Two adjacent sides are first smoothed, care being taken to keep them at right angles to each other. With a gauge, it is then marked to 1¾ inches square and carefully worked to these lines. One end is then dressed with block plane and the piece sawed off and dressed to a length of exactly 12 inches.

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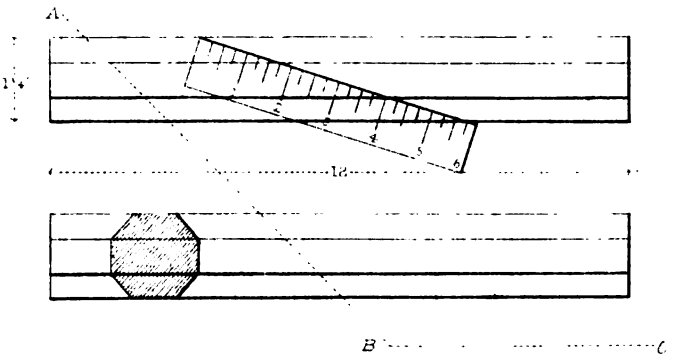
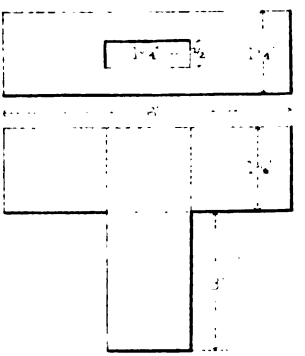
THIRD LESSON.



The finished piece of the last exercise is now taken, and by method illustrated in accompanying cut, is marked so as to be planed to a regular octagon. The bevel is put at angle A B C=135°, so that the work can be tested as it proceeds.

FOURTH LESSON.



THROUGH MORTISE AND TENON.

In this, as in the two following, the piece is gotten out 12 inches long and squared as in No. 2. It is then sawed in two pieces 5½ and 6½ inches in length. Mortise is laid off on 6½ inch piece and tenon on 5½ inch piece, marking being done with knife except when mortise gauge is used. The tenon is cut with the back saw, and the mortise bored and chiseled out. The ends are then cut to proper dimensions.

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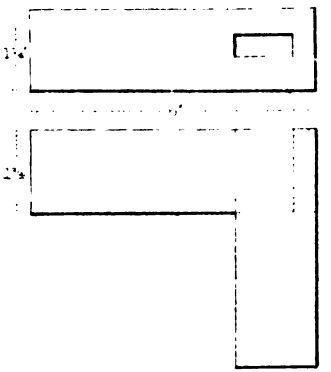
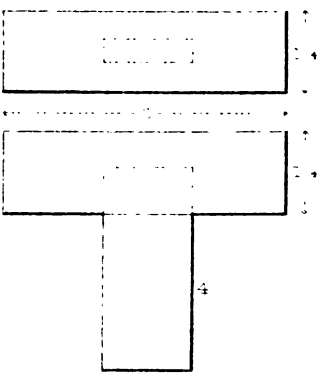
FIFTH LESSON.



POLISHED MORTISE AND TENON.

This piece is merely another form of No. 4, involving the same operations with a few modifications, as can be seen in the drawing.

SIXTH LESSON.



DOUBLE MORTISE AND TENON.

The same as previous lessons, except there are two mortises and tenons instead of one.

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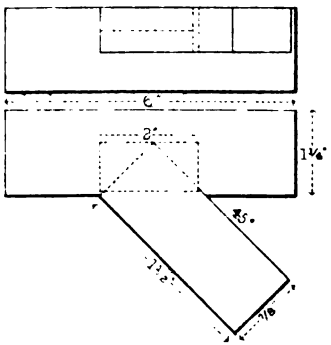
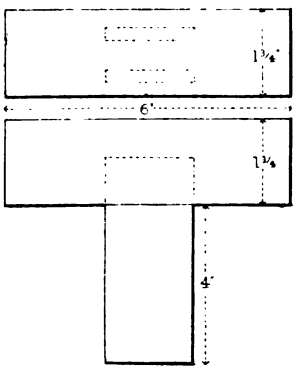
SEVENTH LESSON.



BRACE MORTISE AND TENON.

The brace is put at an angle of 45° and made of material 1½ x ⅞ inches. Tenon is flush with one side of brace and a shoulder cut on end. The whole brace is slightly dropped into mortise piece.

EIGHTH LESSON.



CONCEALED MORTISE AND TENON.

This differs from the preceding only that the mortise does not pass through the piece.

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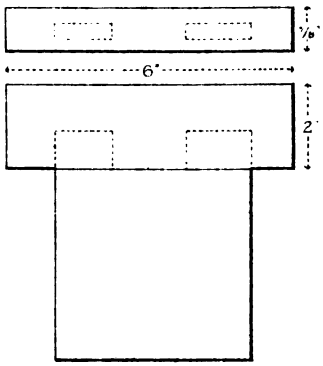
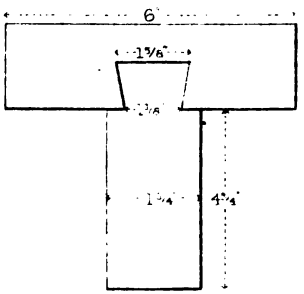
NINTH LESSON.



DOUBLE MORTISE AND TENON.

Another form of double mortise and tenon, made from inch material; differing slightly in detail and being somewhat more difficult to fit.

TENTH LESSON.



OPEN DOVE-TAIL JOINT.

The most elementary form of a dove-tail joint, affording exercise in laying-off and cutting the mortise and tenons at oblique angles.

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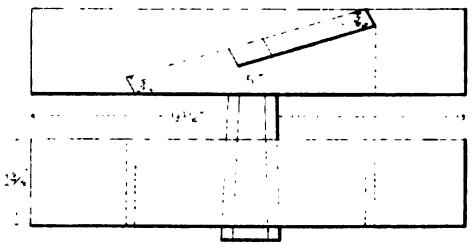
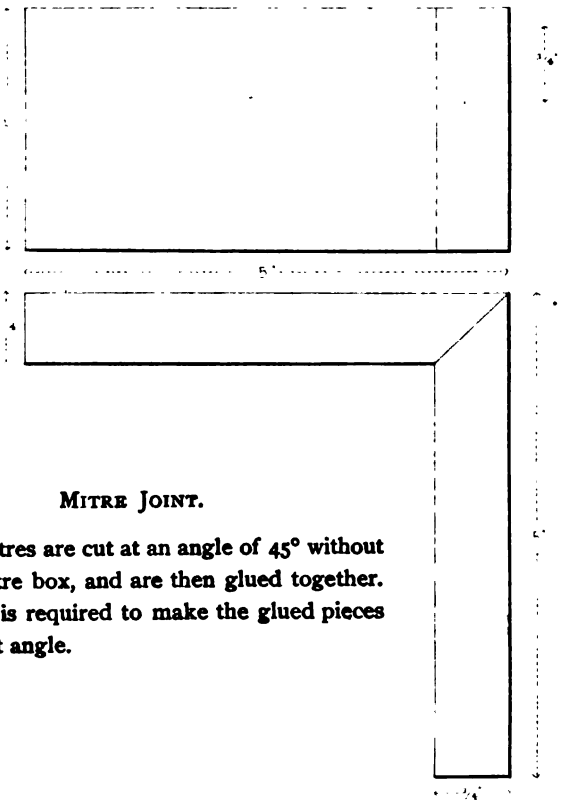
ELEVENTH LESSON.



KEYED SCARF JOINT.

This, on account of its oblique faces and splayed ends, is somewhat difficult to fit. The key forces the pieces into position and securely holds them there.

TWELFTH LESSON.



MITRE JOINT.

The mitres are cut at an angle of 45° without using a mitre box, and are then glued together. Great care is required to make the glued pieces form a right angle.

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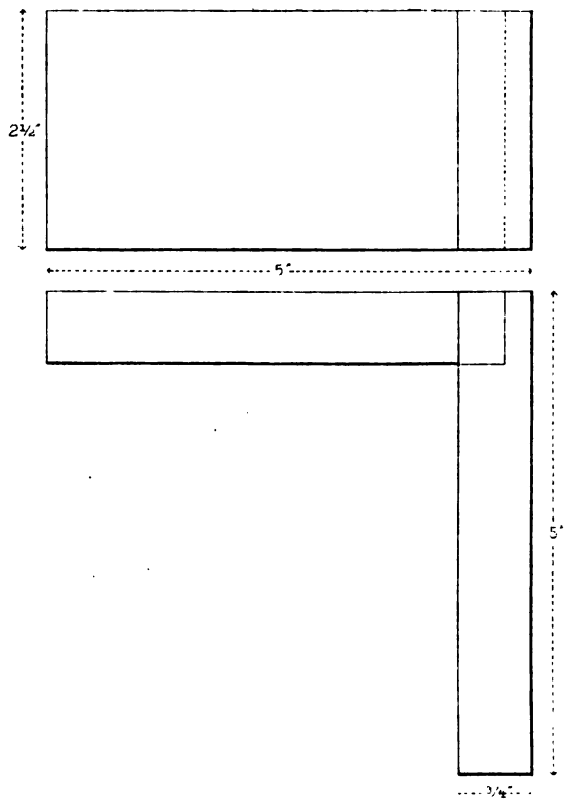
THIRTEENTH LESSON.



LAP JOINT.

In this, as in the preceding one, the difficulty is to make a neat fit at right angles.

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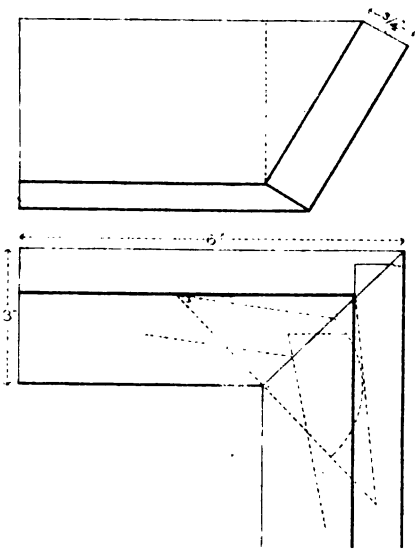
FOURTEENTH LESSON.



HOPPER LAP JOINT.

In the drawing but one angle of the hopper is shown, but the student makes the complete hopper. The method of laying off the work, which is somewhat complicated, is fully explained to him, and in no case is he permitted to proceed until it is laid out with precision.

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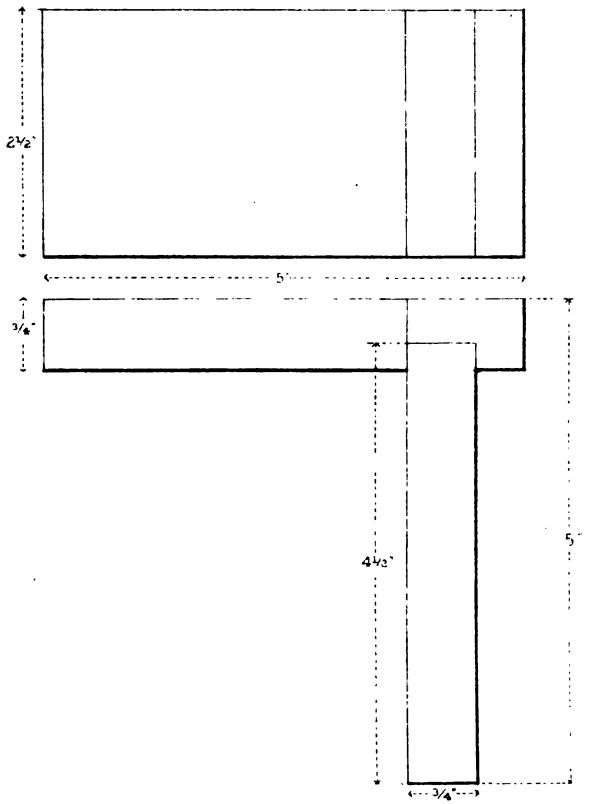
FIFTEENTH LESSON.



GAINED JOINT.

The inner surface of the gain must be flat and true, in order to produce the proper angle. The joint is glued.

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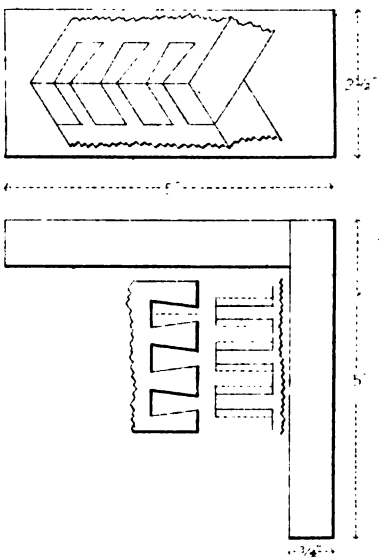
SIXTEENTH LESSON.



LAP DOVE-TAIL JOINT.

A more difficult form to lay off, cut and dress.

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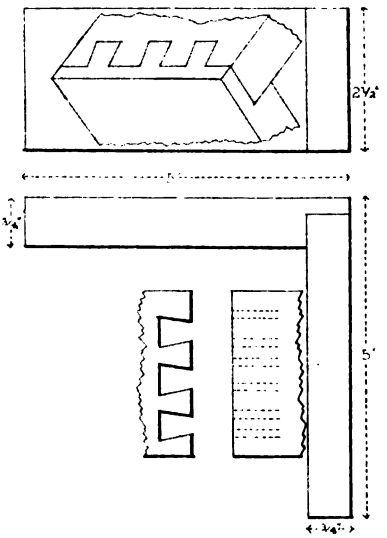
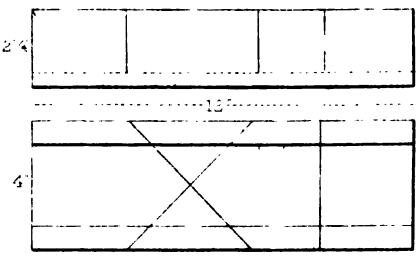
SEVENTEENTH LESSON.



THROUGH DOVE-TAIL JOINT.

The simplest form of a dove-tail joint at right angles, affording practice in laying off, cutting and dressing the corresponding parts to exact form and dimensions.

EIGHTEENTH LESSON.



MITRE BOX.

The box is for subsequent use in sawing mitres and must be made with great precision, angles, and right angles, and bottom of uniform width.

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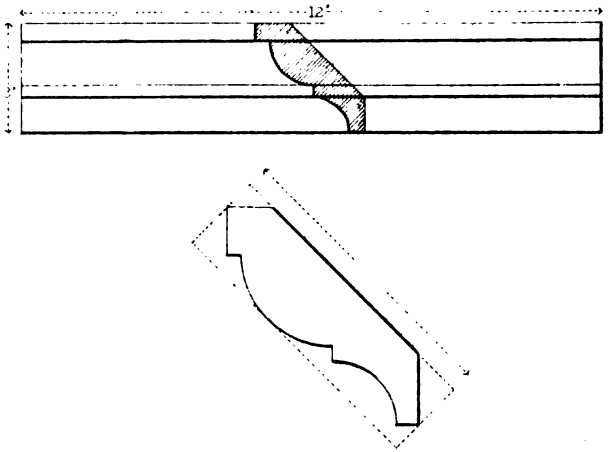
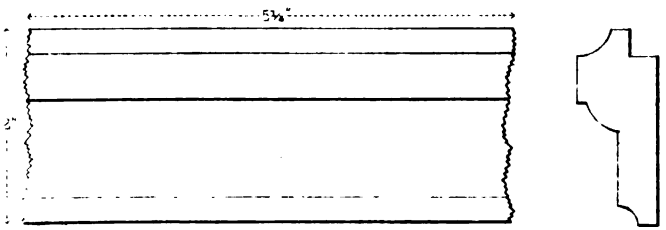
NINETEENTH LESSON.



MOULDING.

In this the work is laid off from an oblique section as indicated in drawing, but of full size. The drawing of the oblique section is laid upon the material at the proper angle and pricked through, thus marking the lines at which the surfaces change direction. The proper tools are now taken and the material worked to the desired form. The hollow and rounding planes are used here for the first time.

TWENTIETH LESSON.



ANOTHER FORM OF MOULDING.

Much as the former, except here a right section is taken from which to lay off the work, and the marking is done on the end of the piece.

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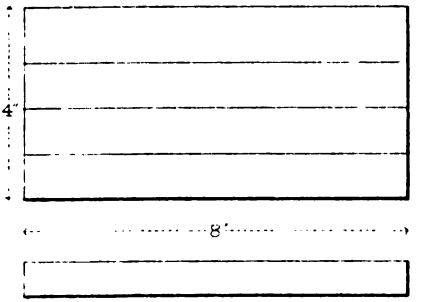
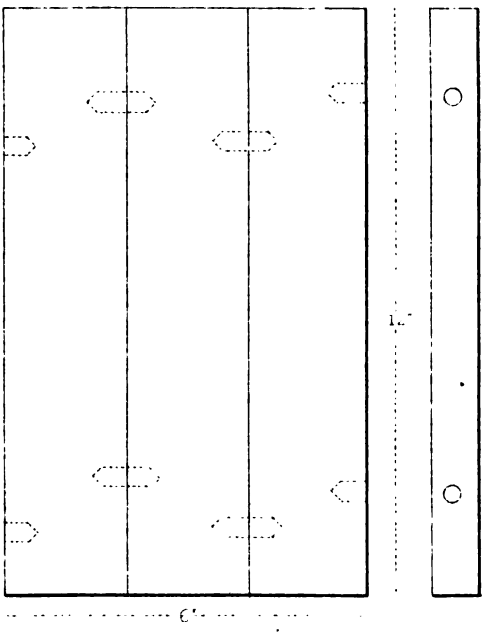
TWENTY-FIRST LESSON.



GLUE JOINTS.

This is made from alternate Cherry and Walnut strips so that the quality of the work can be seen at a glance.

TWENTY-SECOND LESSON.



DOWEL JOINTS.

In this also two kinds of wood are used alternately. The drawing shows the nature of the work.

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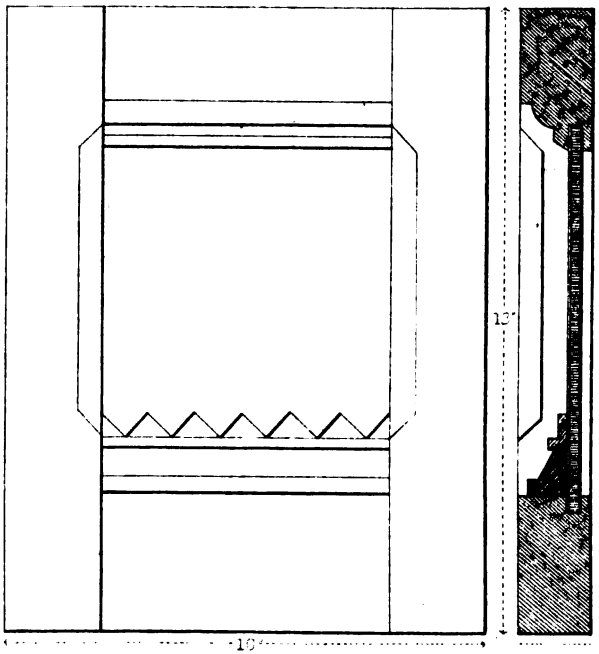
TWENTY-THIRD LESSON.



GOTHIC PANEL.

This exercise affords a variety of work. The inner edges of stiles are chamfered, the upper rail has moulding worked upon it, and the bottom of panel is veneered along the top of a piece of moulding placed above the lower rail. The panel and veneer are made of fancy woods, thus presenting a handsome appearance when completed.

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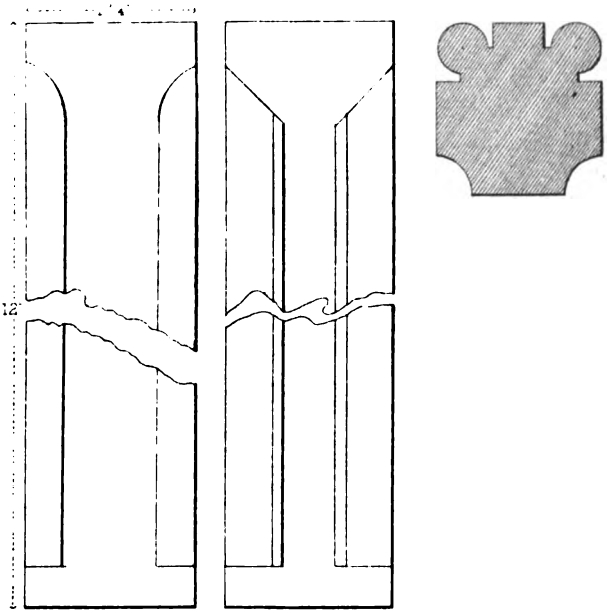
TWENTY-FOURTH LESSON.



WOOD CARVING.

The work is laid off with gauge, after the stick is dressed square. Templates are made from curves in full size sectional drawings. The cutting is done with chisels and carving tools, the templates being frequently applied in order to keep the moulding of proper shape and uniform size.

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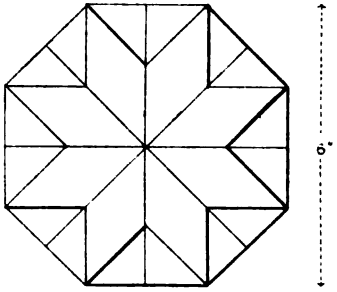
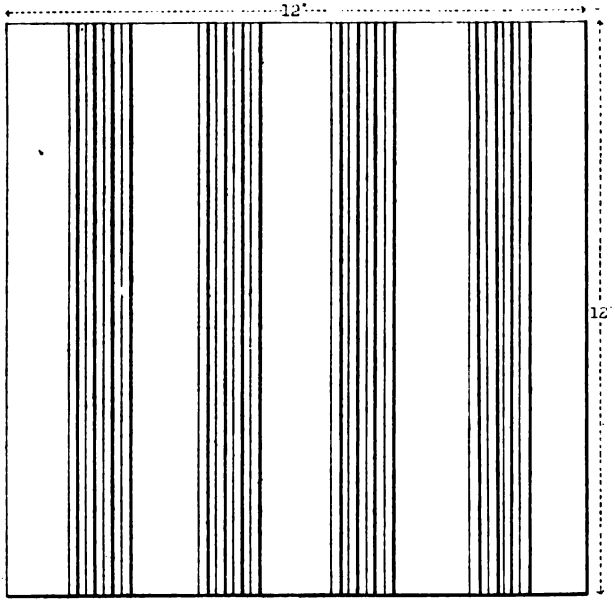
TWENTY-FIFTH LESSON.



ORNAMENTAL VENEERING.

The different pieces of veneer are made of different kinds of wood, thus producing a beautiful effect. It requires considerable care to bring the lines of divisions as indicated in the drawing.

TWENTY-SIXTH LESSON.



ORNAMENTAL INLAYING.

Seven narrow strips of different kinds of veneer are glued together, so as to form a piece ¾ inch wide. That is then inlaid in a solid piece of hard wood, as shown in the drawing, a number of them being placed at regular distances apart.

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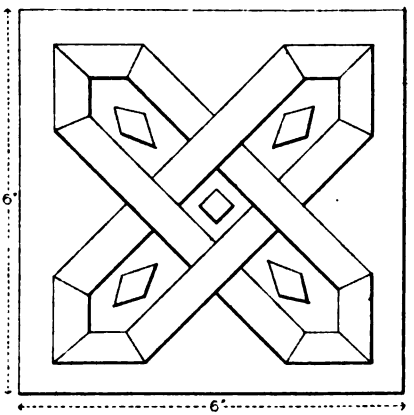
TWENTY-SEVENTH LESSON.



MARQUETRY.

The narrow strips and diamond shaped pieces are inlaid and made of different wood from the block into which they are put.

Machine Work in Wood.

The appliances for this work are as follows: Six wood-turning lathes, strained scroll saw, planer and circular sawing machine. With each lathe is a set of six turning chisels, a set of six gouges, a parting tool, a pair of calipers, a pair of compasses, a try-square, a two-foot rule and an oil can.

In this course not only the use of tools is necessary, but the eye must be carefully trained, as many of the varied forms which arise in wood turning are tedious and difficult to measure. A skilled workman should, therefore, be able to produce work without measuring the smaller details that shall conform substantially to the drawing.

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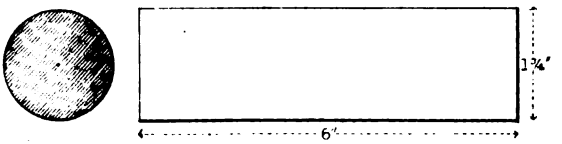
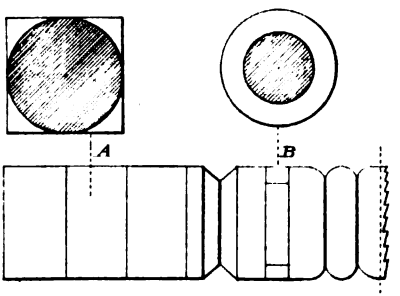
FIRST LESSON.



A CYLINDER.

A piece nine inches long and two inches square is taken. The corners are turned off and it is worked down to nearly the desired size with the gouge. The chisel is then used to work it to the given dimensions, which is determined by frequent application of the calipers.

SECOND LESSON.



COMMON CUTS IN TURNING.

The drawing represents half the length, the remaining half being a repetition of what is shown. In this the cutting lines are marked and the depth is gauged by the use of calipers, but the forms of the curves in middle of the piece are determined entirely by the eye.

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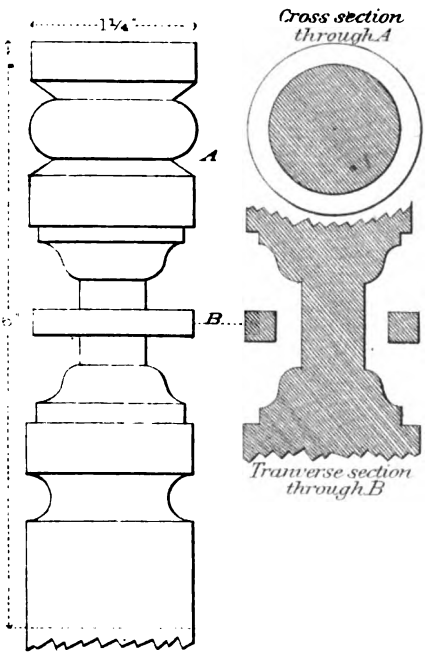
THIRD LESSON.



ORNAMENTAL TURNING.

In this we have a variety of curves, besides a loose ring to be turned upon the small cylinder, as shown in the transverse section in the drawing. The parts are all worked to given dimensions.

These pieces represent the elementary part of the work, and the student is kept upon these until he can produce them accurately and with rapidity.

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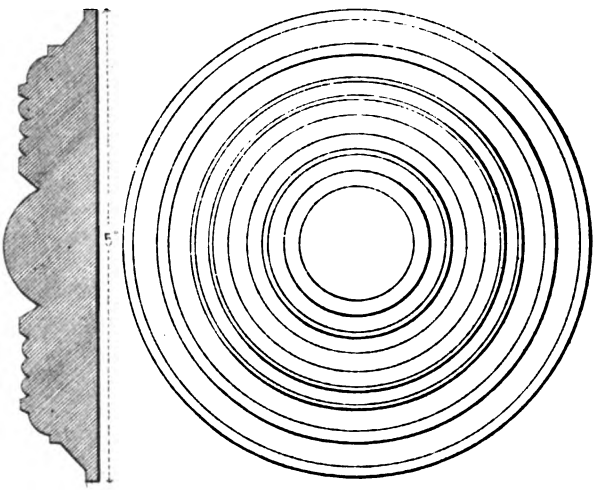
FOURTH LESSON.



FACE PLATE TURNING.

A piece six inches square is fastened upon the face plate from which the rosette, as indicated in the drawing, is to be turned.

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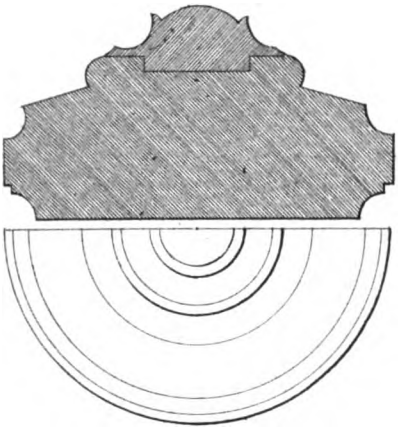
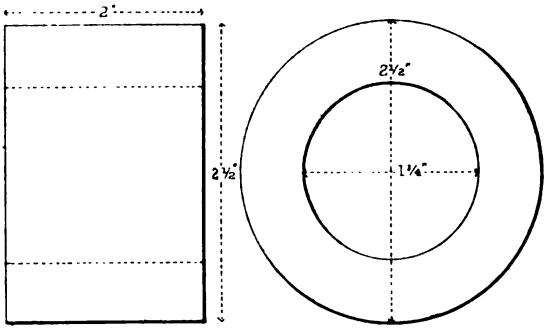
FIFTH LESSON.



NEWEL POST CAP.

The main part of the cap is made of Walnut. The central rosette, which is turned to fit into it, is of Cherry.

SIXTH LESSON.



A CYLINDRICAL RING.

This piece is turned, both inside and outside, and consequently requires two chuckings. It is made of either Cherry or Walnut.

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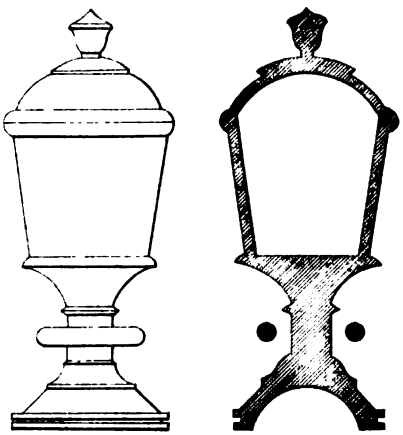
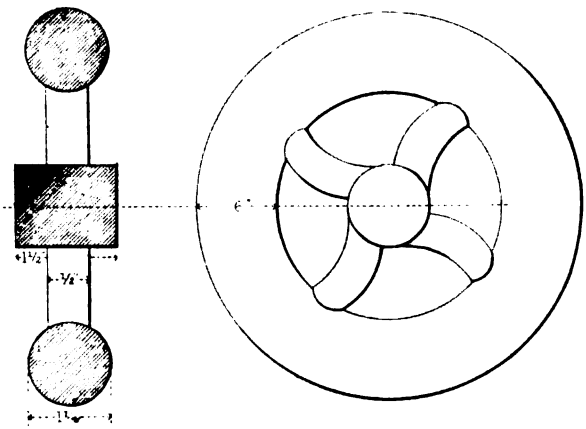
SEVENTH LESSON.



ORNAMENTAL VASE.

As can be seen in section, the vase is made with a lid which fits neatly upon it. The vase is turned both inside and outside as in case of the ring, but here the chucking is more difficult, and fitting the lid requires very careful work. There is a loose ring turned on the stem.

EIGHTH LESSON.



HAND WHEEL.

The rim and hub are turned. The spokes are cut out with saw and chisel.

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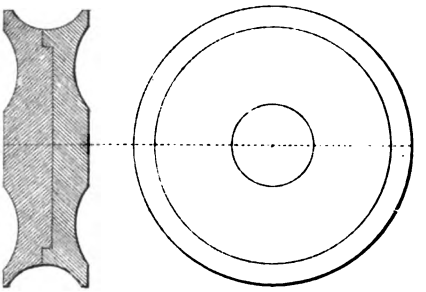
NINTH LESSON.



GROOVED WHEEL.

It is made in two pieces, each of which is turned separately on an arbor. The inner part of one is turned the reverse of the other. When worked to nearly the given dimensions, they are both put upon the same arbor, driven tightly together, and finished in this position.

Pattern-Making.

The student is now ready for pattern making, in which he will apply the knowledge and skill acquired in both carpentry and wood turning.

As the applications for patterns extend into nearly every industry, a great variety of forms is required, and from these many courses of equal value might be arranged. In this course, with a few exceptions, we have, therefore, no fixed exercises for each class. After a few preliminary ones, the students are required to make patterns from drawings, previously made of some machine or part of a machine, which they are to construct later in their course.

The fact that the patterns are to be actually used is an incentive to good work. During the construction the student is shown how the grain should lie in the different pieces forming the pattern; where and what allowance is to be made for warping, shrinking, &c., and in what manner the different forms should be constructed to draw properly from the sand. The following plates are only preparatory to this course:

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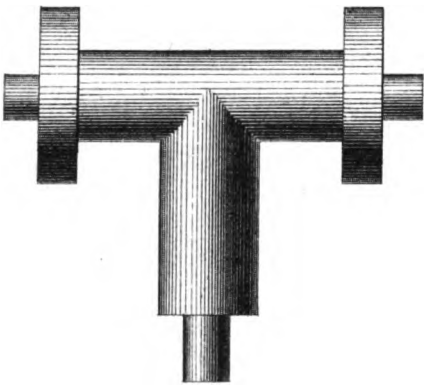
FIRST LESSON.



T PIPE.

The pattern is made in halves.

The body and flanges are first completed, the branch is then made and fitted to the body. Care must be taken that the branch is of such length that the fitting will bring to the size desired.

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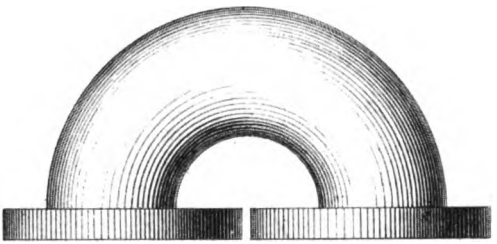
SECOND LESSON.



RETURN BEND.

A ring semicircular in section is first turned of such a radius as desired for the bend. As much of this is then taken as required for the pattern. The half flanges are fastened by screws passing through the center of the pattern into the flange.

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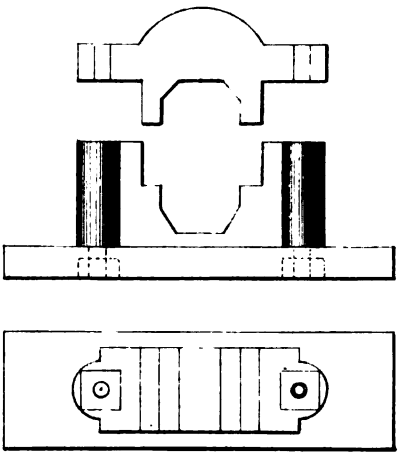
THIRD LESSON.



PILLOW BLOCK.

A piece is first prepared for the base of the desired size, allowing for the contraction of the casting in cooling. The pattern is built up from this as indicated in cut. The student is also required to make the core box.

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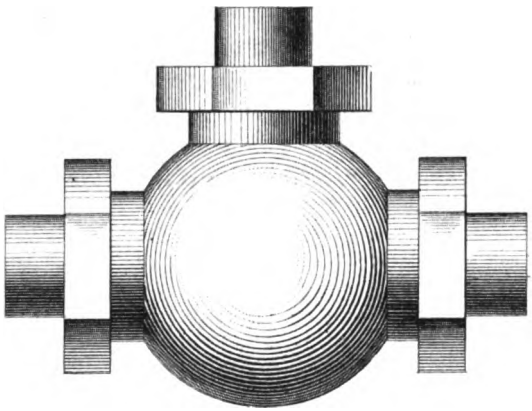
FOURTH LESSON.



GLOBE VALVE.

In this the two pieces of wood are taken of sufficient size, so that when pegged together the ball or body of the pattern can be taken out of them. The branch is then made and fitted to the ball.

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Forging.

For this work there are eight Sturtevant forges, each supplied with blast by a power blower, each provided with an anvil, tongs, punches, heading tools, hot and cold chisels, hammer and a two-foot square. There are also in this room four complete sets of swedging tools, set hammers, flatters, fullers, sledges, two large box vises, and a self-feed post drill. A drawing laid out to the working dimensions is placed in the forge room for reference during the exercise. The piece is then forged in detail by the instructor before the class, calling attention to the important points as he proceeds with the work. The student himself is then required to forge the piece, the instructor giving assistance only in case of necessity.

THE FIRST LESSON

Comprises the building and keeping of forge fires in proper condition upon which, in forging, so much depends. The student is also shown what degree of heat is necessary, and how to determine when that degree is obtained for the successful working of the various forms.

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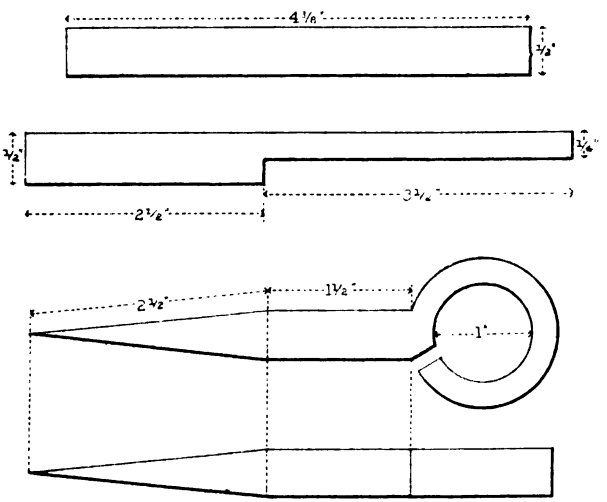
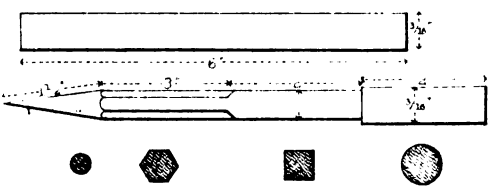
SECOND LESSON.



DRAWING, FORMING AND BENDING.

The successive steps of the exercise are fully explained by the drawing.

THIRD LESSON.



DRAWING AND FORMING.

As seen in the cross sections of the finished piece, a portion is round, another is square, another octagonal and the one end tapered to a round point. The student is here shown that a welding heat is necessary in drawing common iron, otherwise its parts are likely to separate lengthwise.

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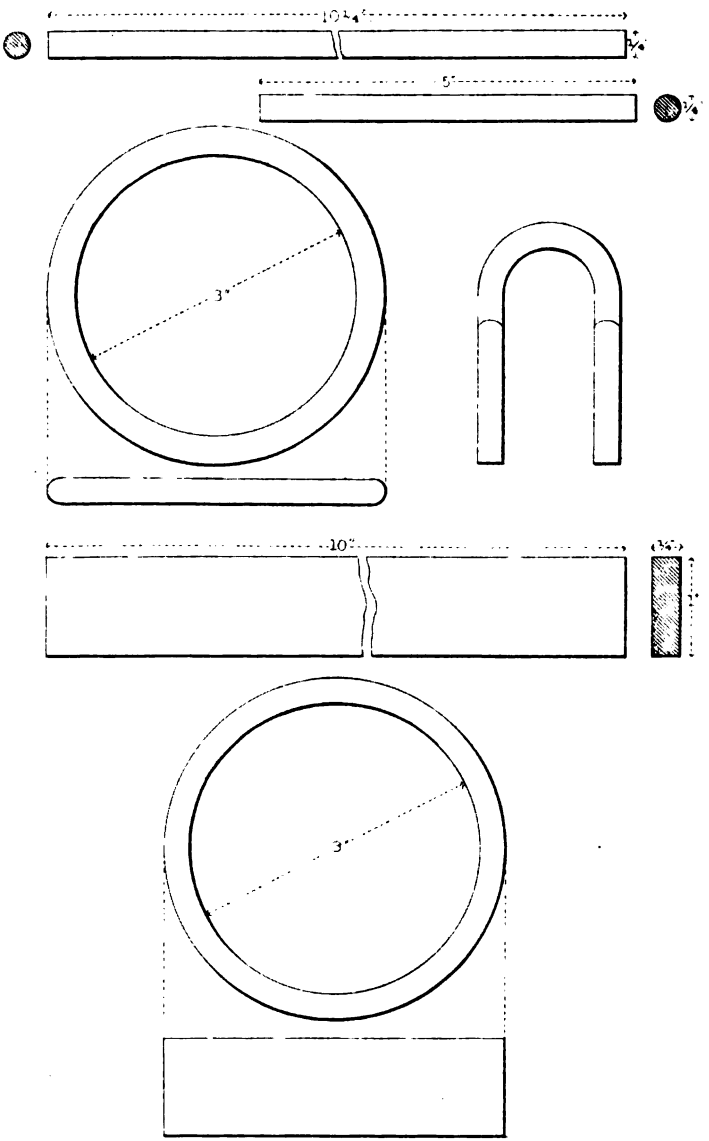
FOURTH LESSON.



BENDING.

One bar each of round and flat iron are bent in circular form and welded. In forming the staples, drawing as well as bending is involved. Whenever possible useful forms are invariably selected, but the introduction of principles is considered of the first importance, and frequently much time can be saved by taking plain forms.

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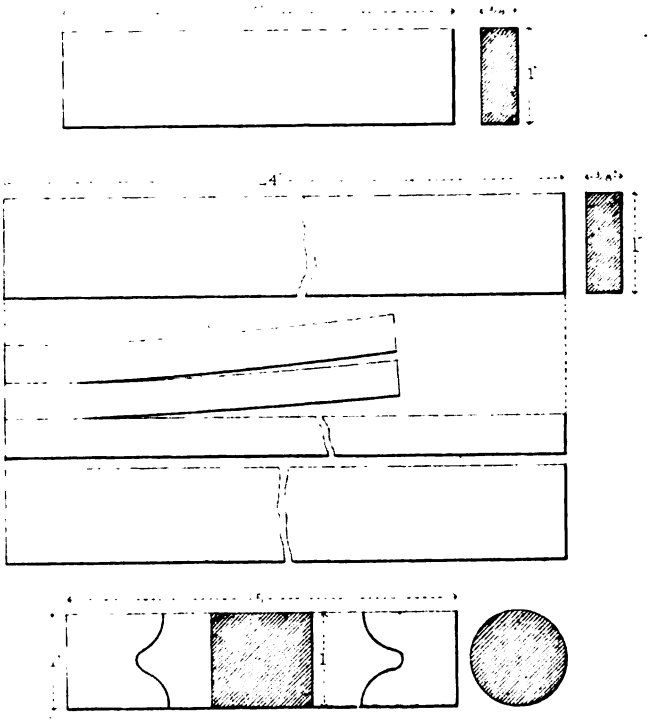
FIFTH LESSON.



FAGOT WELDING.

The one piece is two feet long for the purpose of holding it while welding upon it two four-inch pieces. In welding and rounding the ends, it is drawn out one inch. It is then cut off, and the ends dressed, making the finished piece five inches long.

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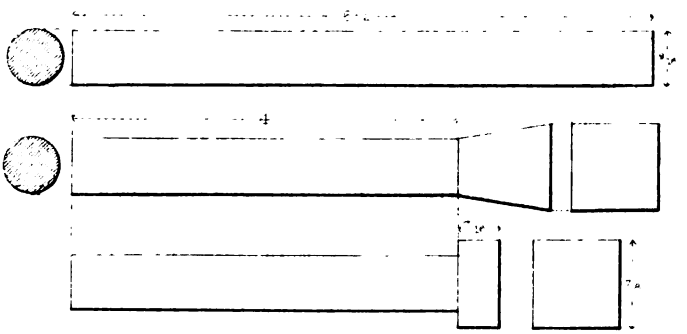
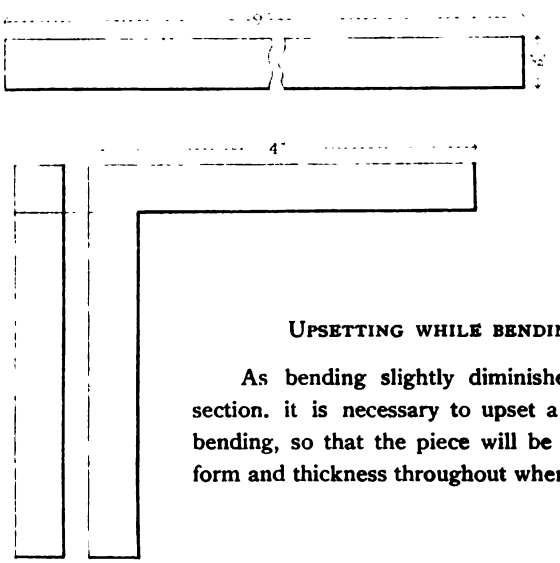
SIXTH LESSON.



UPSETTING AND BOLT-MAKING.

The material is six inches long. By upsetting it is diminished in length, while the part upset is increased in cross section, and squared in preparation for the head of the bolt of the finished piece.

SEVENTH LESSON.



UPSETTING WHILE BENDING.

As bending slightly diminishes the cross section. it is necessary to upset a little, while bending, so that the piece will be of the same form and thickness throughout when finished.

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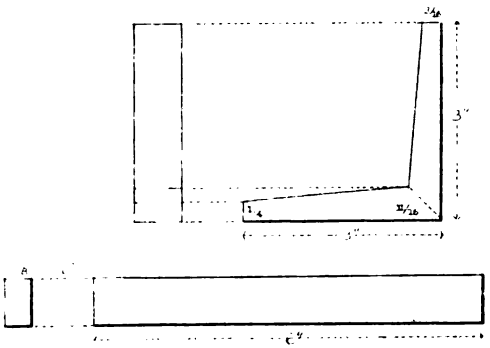
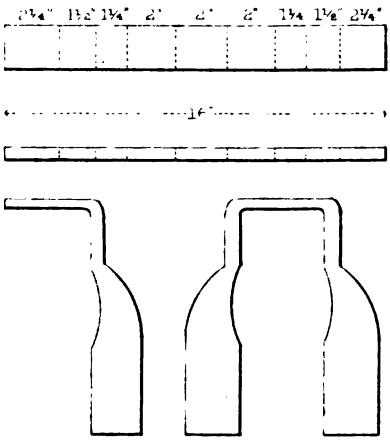
EIGHTH LESSON.



UPSETTING BEFORE BENDING.

This piece is made heavy at the middle, and bent at that point. It makes a much stronger angle than the preceding one.

NINTH LESSON.



BENDING AND TWISTING.

The bar is bent without upsetting. It is a post floor hanger, and is twisted to bring it to the proper shape to receive the timber.

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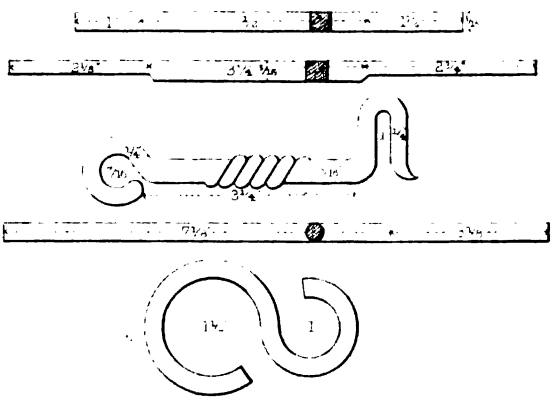
TENTH LESSON.



DRAWING, BENDING AND TWISTING.

The ends are drawn out for hook and eye and made round. The twist in central part is ornamental. The S hook is to accustom the student to forming graceful curves with iron.

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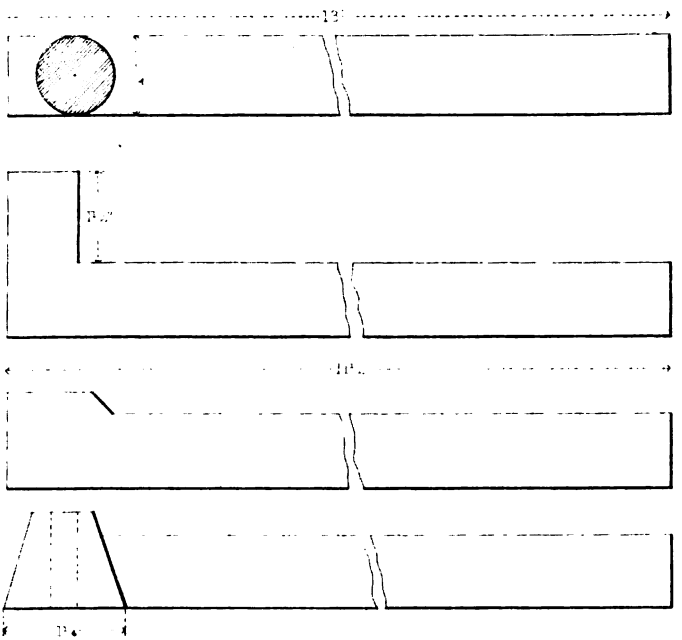
ELEVENTH LESSON.



UPSETTING, WELDING, FORMING AND PUNCHING.

A tool for making the heads of bolts, &c., called a heading-tool.

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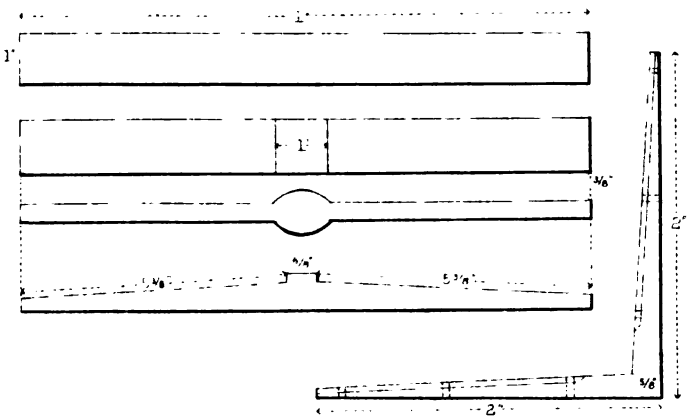
TWELFTH LESSON.



BRACKET.

This involves upsetting, drawing, bending, chamfering and punching.

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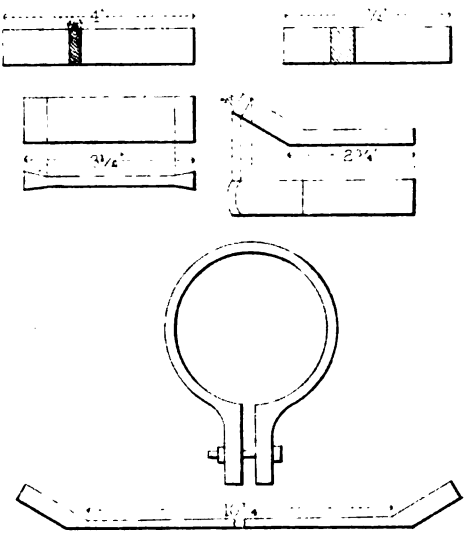
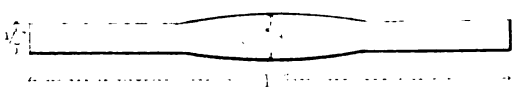
THIRTEENTH LESSON.



RING.

The ring is made from three pieces welded together. The main part being made of lighter material than the ends and angles.

FOURTEENTH LESSON.



BUTT OR JUMP WELD.

The ends are upset and made square after which they are welded by butting them together. Instruction is given as to how the weld should be dressed to preserve its strength.

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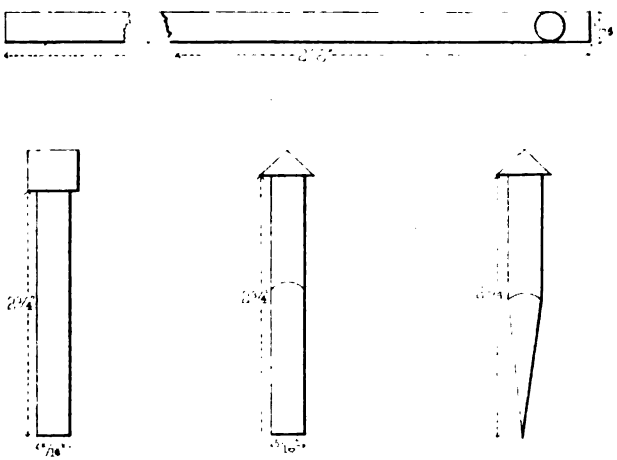
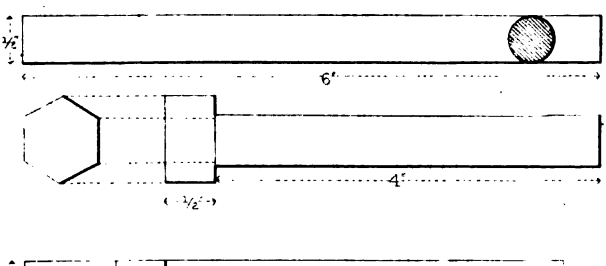
FIFTEENTH LESSON.



BOLTS AND RIVETS.

These are formed with the heading-tool made in lesson eleven. The principal feature in this exercise is to keep the stem in the centre of the head.

SIXTEENTH LESSON.



BOLT-MAKING.

The stock is upset as in a previous lesson, but in this the head is made hexagonal instead of square. Great care is necessary to make the head regular, and as in the lesson above, to keep the body of piece in centre of head.

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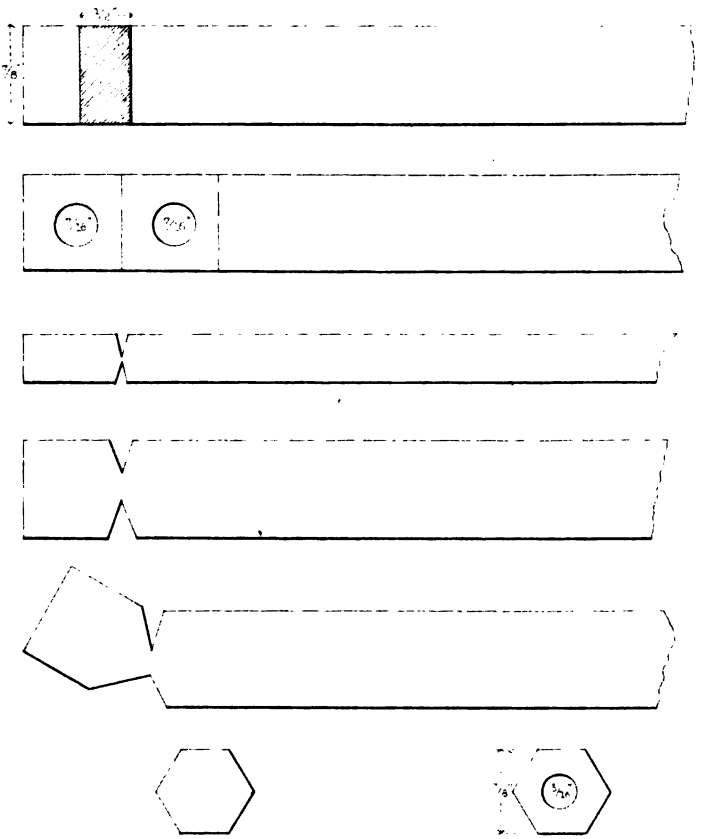
SEVENTEENTH LESSON.



NUTS.

The drawing explains the method of making hexagonal and square nuts.

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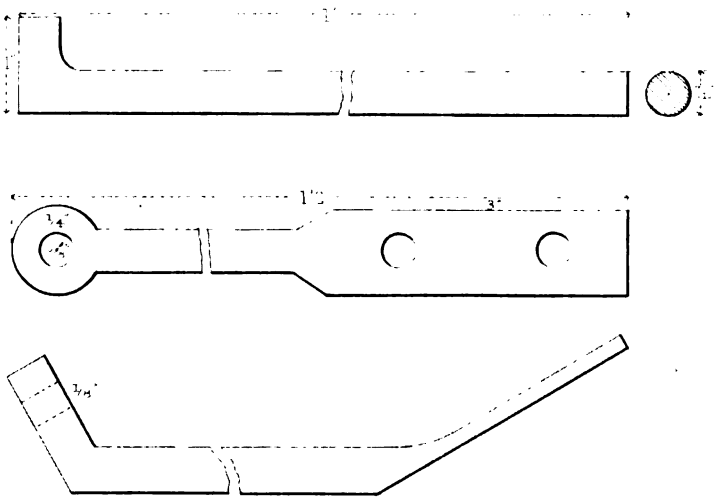
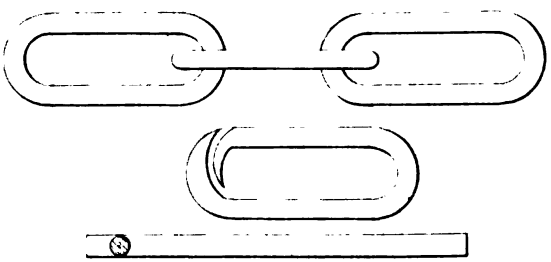
EIGHTEENTH LESSON.



EYE STAY OR BRACE.

The two ends are bent so as to be at right angles to each other while making different angles with the bar. The eye is formed from the body of the piece, while the tang is formed separately and welded on.

NINETEENTH LESSON.



WELDING LINKS.

In this the scarf is somewhat different from that in the ordinary weld. The links are twisted in the finished chain.

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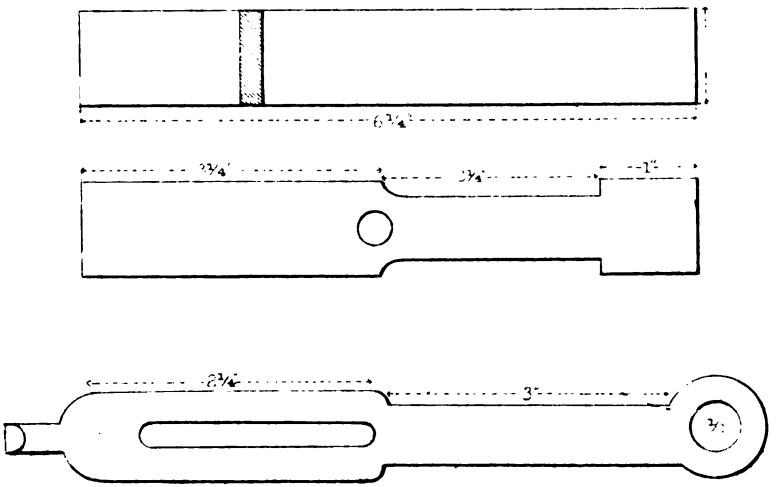
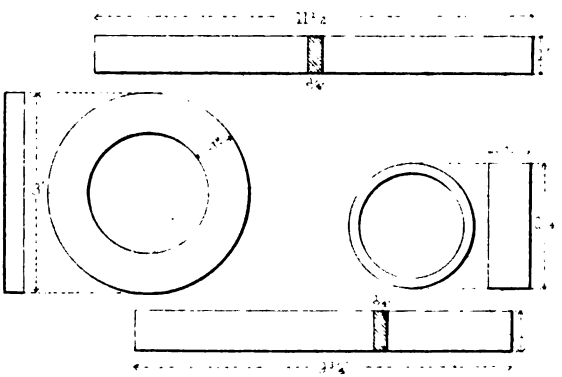
TWENTIETH LESSON.



HASP.

This brings in splitting, in connection with what has been given before.

TWENTY-FIRST LESSON.



Same as in a preceding lesson, except one piece is bent on its edge. The two are put together to show difference in the scarfing.

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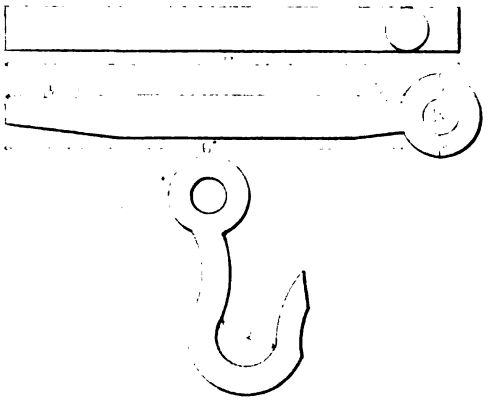
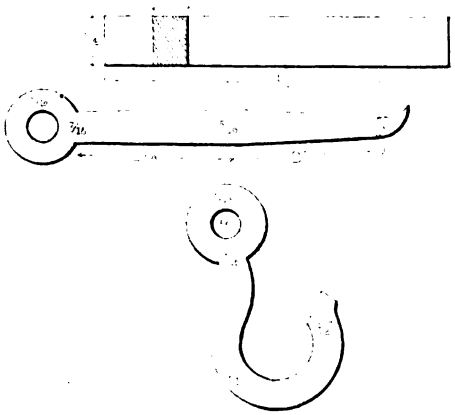
TWENTY-SECOND LESSON.



ROPE HOOK.

The eye is formed by turning and welding it in such a manner as to give it the appearance of being punched.

TWENTY-THIRD LESSON.



CHAIN HOOK.

In this the eye is punched and the greatest care is taken to give it the maximum strength with the material used.

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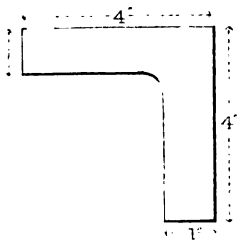
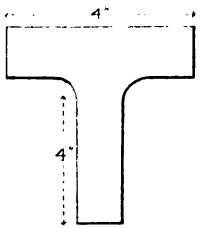
TWENTY-FOURTH LESSON.



WELDED CORNER.

Two pieces welded at right angles, illustrating the kind of scarf necessary for this weld.

TWENTY-FIFTH LESSON.



T WELD.

In this the pieces are welded in the form of a T. The scarf is somewhat different and the weld is more difficult to make.

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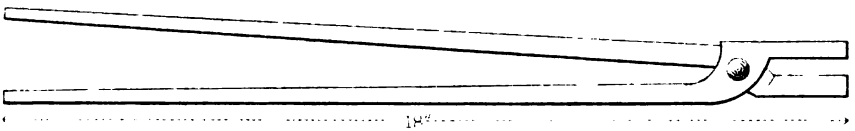
TWENTY-SIXTH LESSON.



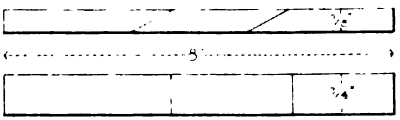
BLACKSMITH TONGS.

The jaws are made from ⅞ inch square iron and welded to lighter pieces for the handles. This exercise combines nearly all the principles that have been gone over in former lessons and closes the course in iron forging.

Steel Forging.

The student has now acquired considerable skill in producing forms, as well as regulating heat in the working of iron. In working steel slight variations are necessary, but he soon becomes familiar with these and is ready to take up hardening, tempering and annealing, which are of supreme importance in the making of tools, &c.

TWENTY-SEVENTH LESSON.



WELDING.

Steel to iron and steel to steel by lap weld.

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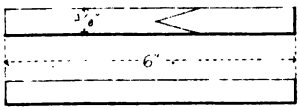
TWENTY-EIGHTH LESSON.



IRON AND STEEL WELDING.

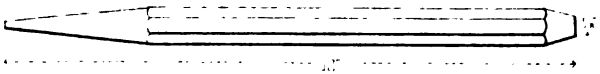
Steel welded to iron by split scarfing.

TWENTY-NINTH LESSON.

WRENCH.

This is formed here to be finished in the filing course which follows. The student here finds the difference between working iron and steel.

THIRTIETH LESSON.



BLACKSMITH'S PUNCH.

After forging it is hardened and tempered.

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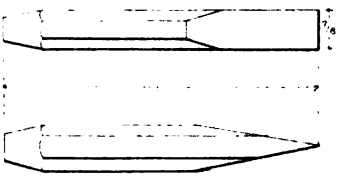
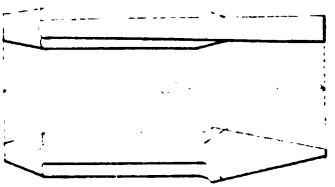
THIRTY-FIRST LESSON.



FLAT COLD CHISEL.

The forging is a sample form, but it gives practice in tempering.

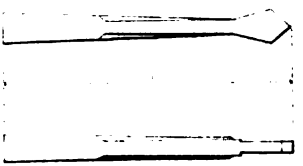
THIRTY-SECOND LESSON.



CAPE CHISEL.

Forming and tempering.

THIRTY-THIRD LESSON.



DRILL.

Here the form is somewhat more difficult to produce, and is tempered to a dark straw color instead of a brown, as in the two preceding lessons.

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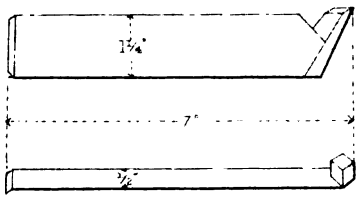
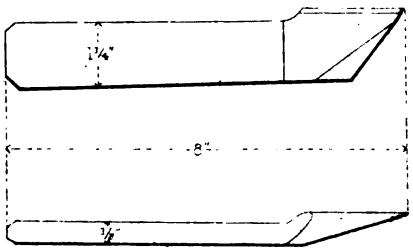
THIRTY-FOURTH LESSON.



LATHE TOOL.

Forged as indicated and properly tempered.

THIRTY-FIFTH LESSON.



SIDE TOOL.

These tools are comparatively easy to form after the course in iron forging, but close attention is necessary to properly temper them.

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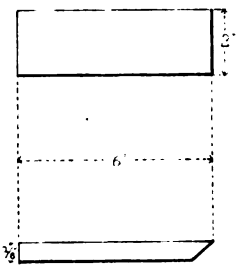
THIRTY-SIXTH LESSON.



PLANE IRON.

In the preceding lessons on tempering the pieces have been hardened on or near the cutting edge while in this the whole piece is tempered.

Vise Work.

For this work the shop is provided with eight swivel vises, and a supply of small tools, as follows: Cold chisels of different forms, chipping hammers, an assortment of files, file cards, try-squares, calipers, scratch gauges, hand vises, &c., &c. This course is intended to give practice in the use of different hand tools for metal, and also to teach the student how to keep them in order. Each lesson is varied in such a manner as to insure the introduction of the different shaped files. The castings are planed, not true, to remove the rough scales which are so injurious to files.

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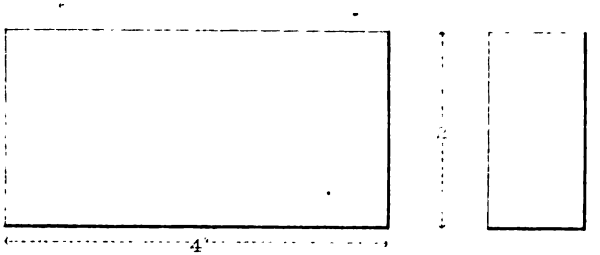
FIRST AND SECOND LESSONS.

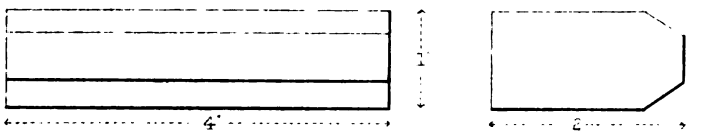


FILING TO LINE.

I. A plain block of cast iron is taken, and one face is filed true. The student is taught how to hold the file and move the arms to produce a true surface.

II. An edge and end are filed square with true surface, using a try-square to test the accuracy of the work.

THIRD LESSON.



FILING HALF HEXAGON.

The same casting is used as in lessons one and two. The student lays out a half hexagon on the end of the piece, lines it, and then files it to the lines as indicated in the figure.

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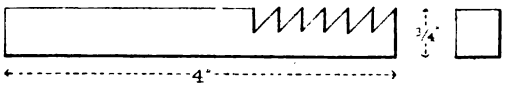
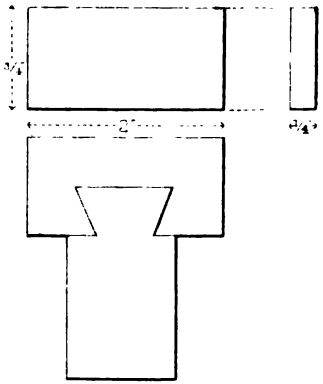
FOURTH LESSON.



RACK-TEETH.

This piece shows the different files used to form sharp angles of this kind.

FIFTH LESSON.



DOVE-TAILING.

The piece being of wrought iron shows the difference of working the two metals. It introduces drilling, sawing and filing.

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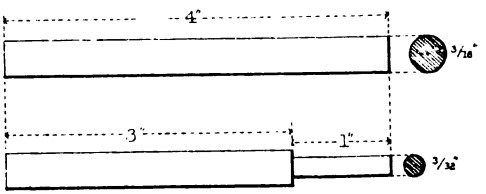
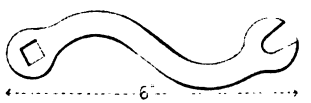
SIXTH LESSON.



SCREW BLANK.

This is reduced in size its entire length; then a portion is reduced more than the other forming a shoulder, the reduced portion being kept round in section and in the centre of the stock.

SEVENTH LESSON.



WRENCH.

The wrench made in the forging course. It introduces inside and outside curves, and a square hole to be filed from a round one.

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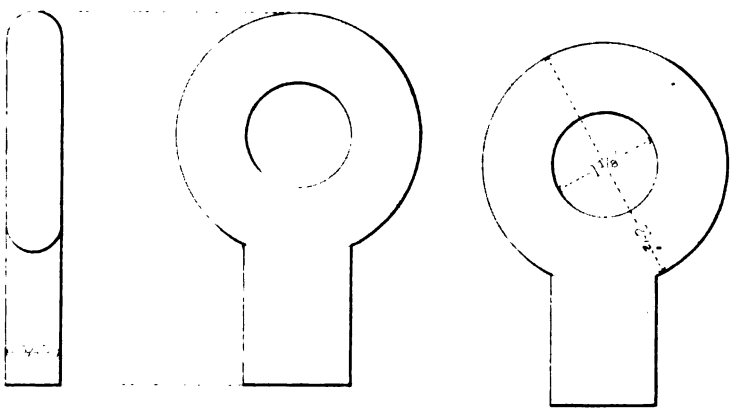
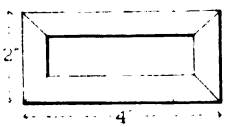
EIGHTH LESSON.



RING WORK.

The material for this exercise is on the right in the drawing and two projections of the finished piece are on the left. The object is to make the ring circular in section from the casting which is square in section, and to make all the surfaces of the tang straight and at right angles to each other.

NINTH LESSON.



CHIPPING BEVEL.

The casting is lined by the student the proper distance from the edge which is to be beveled. It is cut down to the line, using a hammer and flat cold chisel.

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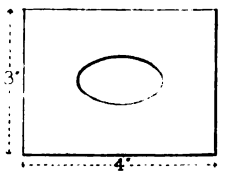
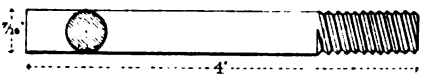
TENTH LESSON.



OVAL FILING.

A flat piece of cast iron upon which an oval shape is marked out. It is drilled out as near to the marks as possible, and then chipped and filed to the line.

ELEVENTH LESSON.



THREAD CUTTING.

A line representing the thread is marked off twelve times around the piece, the pitch being kept the same throughout. The filing is done by using the half-round and three-cornered files.

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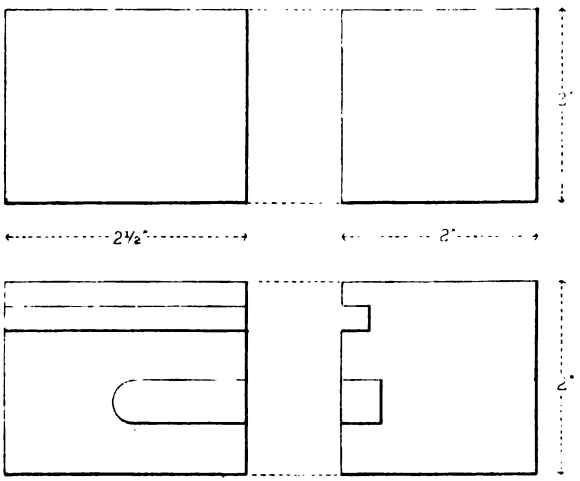
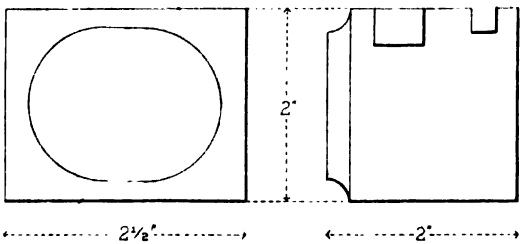
TWELFTH LESSON.



CHIPPING (WROUGHT IRON.)

A rectangular groove ¼ x ¼ inch is chipped entirely across the face of the piece, and another groove ½ x ⅜ inch three-eighths of the distance across.

THIRTEENTH LESSON.



CHIPPING.

Same block is used. An oval is cut upon one side introducing concave chipping, as is shown in the right-hand projection.

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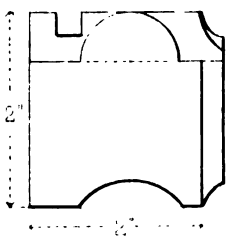
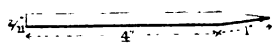
FOURTEENTH LESSON.



CONVEX CHIPPING.

Here, on same block, is introduced convex chipping in the form of a half cylinder part way across the face of the piece. Also, more concave cutting.

FIFTEENTH LESSON.



HAND VISE FILING.

A round piece of steel is reduced in diameter its entire length and filed at one end to a tapering joint.

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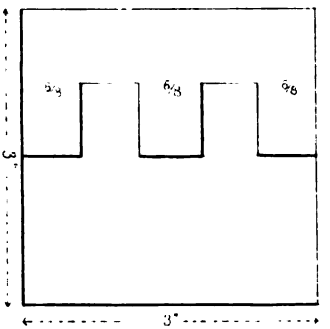
SIXTEENTH LESSON.



PARALLEL FITTING.

The casting is lined by the student and fitted as shown in the plate. The practice which he has acquired is here called into use, as one misstroke of the file may necessitate his beginning a new piece.

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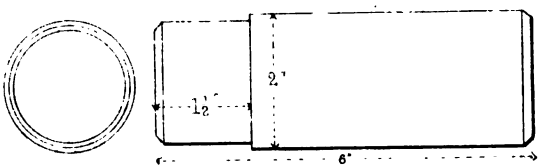
Machine Work in Iron.

In this course, after a few elementary pieces, the student is required to build some machine. If it is too large for one to complete during his course, more students are put upon it, and in this way a working piece of mechanism is produced, the result of their combined efforts. We hope, by this method, to add to our equipment special machines designed and built by our own students in mechanical engineering. Some little work has already been done by special students. Below will be found a few of the elementary lessons required by all students who enter upon this work.

SECOND LESSON.



PLAIN TURNING.

The piece is centred, put upon the lathe and ends faced up, making it exactly six inches in length. It is then turned down its entire length to two inches in diameter. A portion of it is then cut down to a smaller diameter, leaving a square shoulder one and one-half inches from the end. The ends are then chamfered. The exercise gives practice in selecting, grinding and setting the proper cutting tools.

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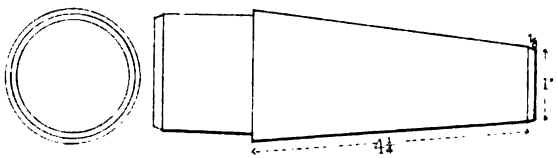
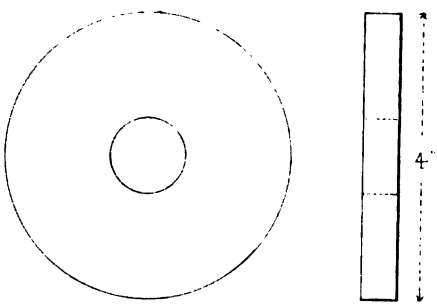
THIRD LESSON.



TAPER TURNING.

The finished piece of last exercise is taken for the stock of this. The object of this lesson is to show how, by moving the toil stock to the front or rear, any desired taper may be turned.

FOURTH LESSON.



CHUCKING AND BORING.

The solid blank is centred, and then bored out by placing the drill in the slot of tool posts and using toil stock to force drill through.

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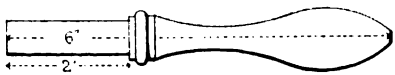
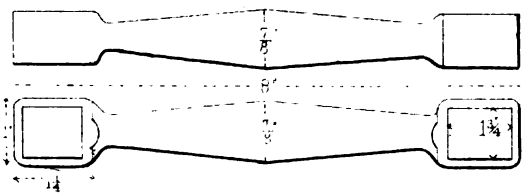
FIFTH LESSON.



A HANDLE.

This lesson gives practice in using the cross feed by hand to produce a given curve, while the longitudinal feed is operated by the lathe.

SIXTH LESSON.



CONNECTING ROD.

This involves about all the principles of the preceding lessons besides some planer work.

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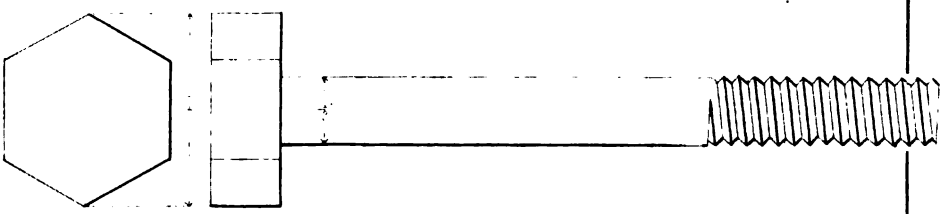
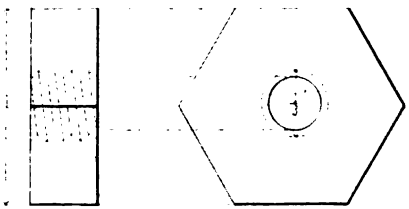
SEVENTH LESSON.



SCREW CUTTING.

The student is shown how to arrange the gearing for cutting threads of different pitch. He then cuts twelve threads to the inch upon the bolt given him.

EIGHTH LESSON.



INSIDE SCREW CUTTING.

The thread is cut for the bolt in the preceding lesson.

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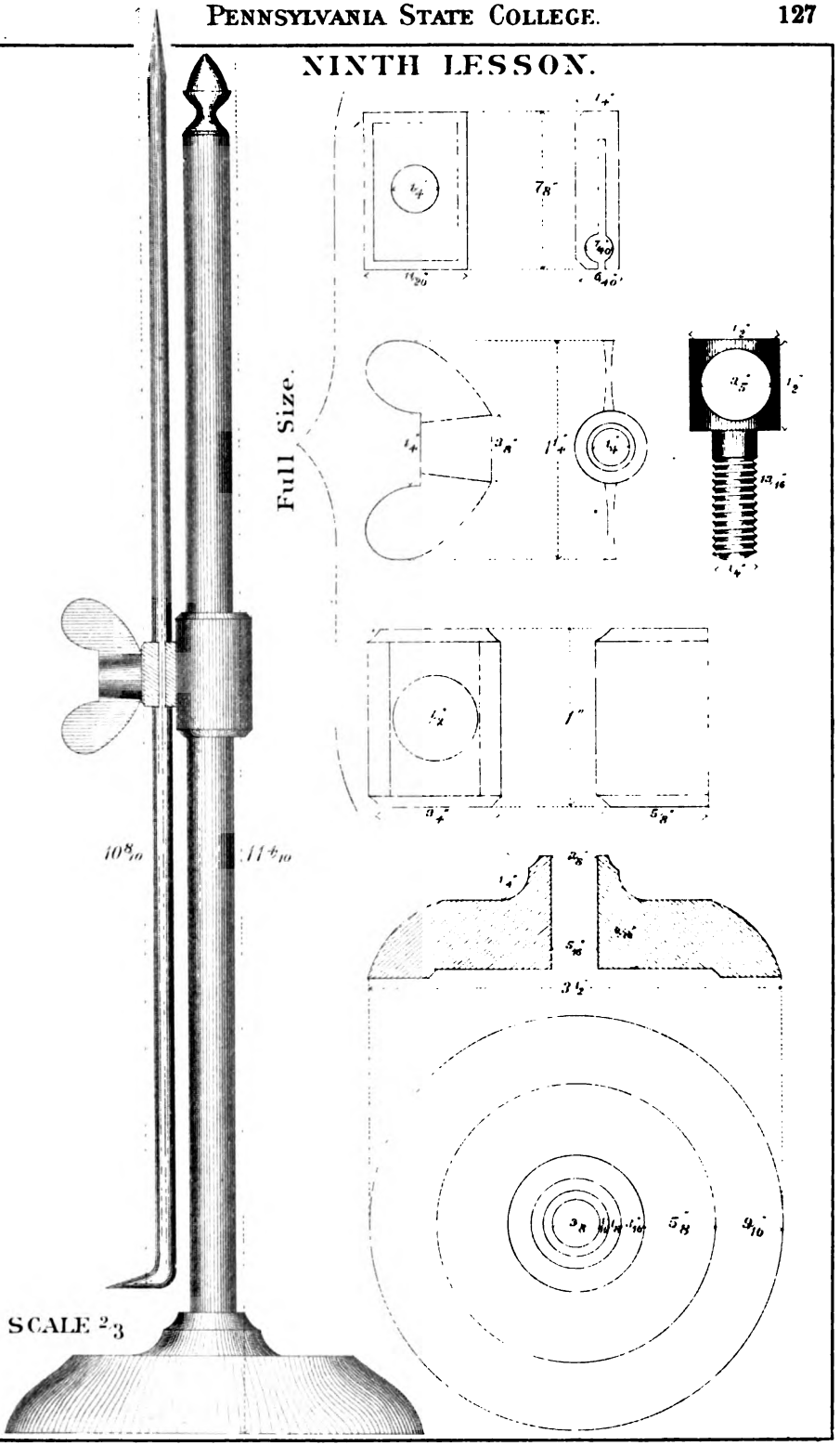
NINTH LESSON.



SURFACE GUAGE.

MADE BY STUDENTS IN THE PENNSYLVANIA STATE COLLEGE.

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12. MILITARY.

State College, Pa., *December 12, 1888.*

Geo. W. Atherton, LL. D., *President:*

Sir: I have the honor to submit the following report for the year 1888.

Military exercises have taken place during the past year as per schedule.

Progress has been satisfactory, especially so, considering the corps has been without the use of a proper armory. It is hoped, however, the fine new one will soon be ready for use

The College can certainly congratulate itself in having one of the finest college armories in the country.

The Corps derived much benefit from its five days' encampment near Hunter's Station in May.

Major H. J. Farnsworth, inspector United States Army, made an inspection of the battalion in June. No suggestions were made by him.

The commandant is pleased to note the gradual increase of the number of cadets in the battalion. It numbers now 132, double what it was when he came here on duty two and one half years ago. It becomes necessary to ask for fifty more stands of arms from the government.

I would like to see competitive rifle matches between colleges where the government details officers.

The usual appropriation of $50 is asked for.

The following appendices pertain to property received, expended and on hand.

I am, sir, very respectfully,

S. S. Pague,

1st Lt. 15th Infantry, Prof. Mil. S. and Tactics.

Appendix "A."

Ordnance stores received from U. S. Government during year 1888.

100 blank cartridges, 3′ gun.
1,000 rifle cartridges, blank, 45 calibre.
1,000 rifle cartridge balls, 45 calibre.
300 friction primers.

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Appendix "B."

Property purchased, etc.			*Appropriation.*
March	3.	Paper and envelopes,	$3 78
April	25.	C. F. Reeves,	1 33
May	8.	Treasury,	1 70
June	20.	Mechanics arts,	95
July	2.	Treasury,	16 13
July	23.	B. H Beaver,	50
August	3.	Oil,	12
August	4.	Treasury,	3 49
March	6.	M. D. Sneyder,	85
December	—.	Treasury, etc.,	27 25

CR.

April	16.	Appropriation,	$50 00
July September	23. 17.	Students,	6 10

Appendix "C."

Ammunition expended U. S. Government.

1,100 carbine cartridges, ball, 45.
1,000 carbine cartridges, blank, 45.
125 blank cartridges, 3' gun.
300 friction primers.

Appendix "D."

Ordnance and ordnance stores on hand, U. S.

2 3-inch rifles and carriages (complete).
100 Springfield cadet rifles.
10 N. C. O. swords.
100 infantry accoutrements (sets).
100 headless shell extractors.
100 blank cartridges, 3" gun.
600 friction primers.

Appendix "E."

Property on hand, Military department, P. S. C.

1 garrison flag (worn).
1 battalion flag, silk (belt, etc.).
2 marker's flag, silk (belt, etc.).
1 air gun (unserviceable).
12 fencing masks.
1 seat of reloading instruments (unserviceable).
7 officer's swords (with belts, etc.) and 2 *en route*.
1 set N. G. books.
45 cavalry sabres.
19 cavalry sabre belts.

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2 3′ Napoleon guns and limbers.
2 drums (complete).
2 fifes.
4 blank books (record).
1 hammer.
1 desk (pigeon holes).
1 electric bell.
1 telegraph instrument (complete.)

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13. MODERN LANGUAGES.

STATE COLLEGE, PA., *December 31, 1888.*

GEO. W. ATHERTON, LL. D., *President:*

SIR: I have the honor to submit the following report of the Department of Modern Languages for the year 1888:

The number of students has been slightly increased over the number in 1887, in the lower classes. The schedule of work has been the same, except an exchange of hours with Professor McKee during a part of the winter session and the spring session, on account of his sickness. In addition to this the essay work of the Sophomore class, in the spring session, was in the department.

As our classes are growing larger the difficulty of teaching them satisfactorily, under the present conditions, grows greater. To do justice to them, the Freshman class ought, hereafter, to be divided. This would not only make additional labor, but increased difficulty in arranging their schedule of work unless there should be a similar division, say in the mathematics. This recalls a suggestion in regard to dividing the mathematics in such a way as to require a little less work in that line for students not in the technical courses, thus allowing increased opportunity, if thought desirable, for modern language studies, in the sophomore year, at least, of which the department could make good use. A slight readjustment might then be made, so that the technical students would be able to give more time to French, which is desirable.

There has been a suggestion as to offering electives in the senior year of the General Science Course which might open the way for advanced work in this department in the fall or winter sessions, or both.

I earnestly request that the department may be provided with large wall maps of France and Germany for class room reference, which is frequently desirable.

Additional books of reference are also desired, and a large, well lighted recitation room, with plenty of black-board surface, is a necessity.

Respectfully submitted.

CHAS. F. REEVES,
Professor of Modern Languages.

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14. PHYSICS AND ELECTROTECHNICS.

GEORGE W. ATHERTON, LL. D., *President:*

SIR: The following table gives in condensed form a number of facts concerning the work in the Department of Physics and Electrotechnics during the year 1888.

Recitation and Practicum Work.

1888.	CLASS.	No.	Subject and Text-book.	Hours per week.	Practicum hours per week.
WINTER.	Seniors,	4	Practical Electricity, Ayrton & Perry.	3	4
	Seniors 2, Specials 2,	4	Dynamo Electric Machinery, S. P. Thomson.	3	. . . . .
	Juniors,	15	Physics, Anthony & Brackett.	4	4
	Specials,	2	Electricity and Magnetism, S. P. Thompson.	3	6
SPRING.	Seniors 2, Special 1,	3	Dynamo Electric Machinery, S. P. Thompson.	4	8
	Seniors 2, Special 1,	3	Electric Lighting, J. Maier.	4	. . . . .
	Specials,	2	Electricity and Magnetism, J. B. Murdock.	1	. . . . .
	Juniors,	15	Physics, Anthony & Brackett.	4	4
	Specials,	4	. . . . .	. . . . .	4
FALL.	Seniors,	6	. . . . .	. . . . .	4
	Graduates,	2	Theory of Electricity,	4	. . . . .
	Graduates,	1	Dynamo Electric Machinery, S. P. Thompson,	3	. . . . .
	Graduates,	1	Electric Lighting, J. Maier.	2	2
	Juniors,	23	Physics, Anthony & Brackett.	4	4

Number of different students: winter, 21; spring, 18; fall, 31.
Number of hours of recitation per week, 13 each session.
Three distinct lines of laboratory work each session.

The New Course in Electrotechnics.

Several students, when this course was established, arranged for taking so much of it as they could during the two remaining sessions of the college year 1887–8. Though they could get but a limited portion of the course, and under disadvantages, some of them have engaged in electrical work and are doing well.

At present there are two graduate students at work in the course, five of the sophomore class (the first class that could choose it without abandoning a previous choice of course) have regularly entered it, and seven other students are doing some work in it.

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It gives me pleasure to mention the courtesies of several electrical companies, and that thanks are especially due to the Standard Underground Cable Company and to the Westinghouse Electric Company of Pittsburgh, for samples and apparatus freely given to the Department of Electrotechnics.

Conditions and Needs.

All the work of the past year has been done in the old rooms in the second story of the college, limited and entirely insufficient, causing much inconvenience and loss of time and extra labor.

This lack of sufficient and suitable rooms will no doubt be remedied, by the beginning of the next college year, by the completion and occupancy of the new physics building, now under roof.

This building is designed for the following plan of work:

(1) Lecture and recitation work.
(2) Elementary, or general laboratory work.
(3) Advanced laboratory work and research.
(4) Special laboratories, applied physics.

The lecture and recitation rooms are ample. The laboratories for elementary work are large enough to accommodate conveniently as many students as one instructor can properly manage. In this work, under the guidance of an instructor constantly in attendance, the student learns how to work, as well as something of physics.

For the advanced laboratory work, a number of small rooms are provided. The student who has learned how to work under an instructor in the elementary laboratory, being given a room and apparatus for some work of a higher grade, can proceed with it himself as uninterruptedly as his duties permit and his interest may prompt, under the general supervision and advice of the professor. Where the aptitude and attainments are sufficient, this may readily pass into research work.

The special laboratories, for instruction and practice in the application of physics to the useful arts and industries, are such as the photographic laboratory, and dynamo-electric laboratory, in which provision is made for so much as possible of the operations and methods employed in the practice of the arts.

The need of liberal appropriations for the equipment of this department is very great. I shall be glad to give more detailed statements whenever there may be occasion.

General Remarks.

Not for supplying equipment, but for the running expenses to keep the work going during the coming year will require $150 to $200.

A few things of most immediate and imperative need for slightly advancing the work will require about $200.

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The Notes on Experimental Dynamics printed in the report for last year (mainly from the note books of 1886) have been of great advantage in the work this year. I have a pretty thorough revision, with corrections and additions, nearly prepared.

Mr. George C. McKee, who was appointed assistant in the physical laboratory, early in the year, has rendered efficient aid, and I am glad that arrangements have been made by which he continues in that position; understanding the laboratory and the work from experience, and taking an earnest interest in it, his services will be yet more valuable to the Department.

Respectfully submitted,

I. THORNTON OSMOND,
Professor of Physics.

STATE COLLEGE, PA., *January 9, 1889.*

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15. TREASURER'S REPORT, DECEMBER 31, 1888.

To the Board of Trustees of The Pennsylvania State College:

GENTLEMEN: The following statement of the accounts of the Treasurer for the year ending December 31, 1888, is hereby respectfully submitted:

The receipts and expenditures for the year have been unusually large, the increase being due to appropriations by the State and National governments in favor of the College, as well as to the consummation of the sale of the Eastern and Western Experimental Farms. These moneys received by the College are, for the most part, specifically appropriated, and accounts are to be rendered, from time to time, showing the amounts received and the purposes for which the funds have been expended.

It became necessary, therefore, for the Treasurer to open a separate account with each fund, and this report is consequently made up of several statements, showing the receipts and expenditures of each.

The first account is the "*General Account*," into which the interest from the Land-grant fund, the receipts from students, College farm, and the general income of the institution are deposited, and from which the salaries of the professors, the expenses of the various departments of the College, ordinary repairs, interest on the funded debt, and the general running expenses of the College are paid.

The second account is "*The State Appropriation Account.*" Into this account is deposited all money received under the act of the Legislature of June 3, 1887, which appropriates one hundred thousand dollars to the College for the various purposes specified in the act, as follows:

Building for Department of Chemistry and Physics, . .	$35,000 00
Equipment for the same, ...	5,000 00
Green-house and Botanical Laboratories, ...	5,000 00
Two dwellings, ...	8,000 00
Drill Hall and Assembly Room, ...	20,000 00
Insurance and repairs on College buildings, ...	9,500 00
For introduction of gas, ...	5,000 00
Machinery and Apparatus for the Department of Mechanic Arts and of Mechanical and Civil Engineering, ...	8,000 00
Books for the Library, ...	3,000 00
Models and Casts, ...	1,500 00
Total, ...	$100,000 00

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The entire amount due the College, as above stated, has been received, and a full statement of the account, from the date of its opening to December 31, 1888, is herewith presented.

The third account is "*The State Experiment Station Account.*" A provision in the act of June 3, 1887, above referred to, appropriates the sum of three thousand dollars for four years, beginning on the first day of April, 1887, in equal quarterly payments, to be used for the work of an *Agricultural Experiment Station.*

The fourth account is "*The United States Experiment Station Account.*" The moneys received into this account are those that are paid to the College by the Treasurer of the United States, under act of Congress known as the *Hatch* Act, which appropriates fifteen thousand dollars each year for establishing and maintaining an Agricultural Experiment Station. The appropriations date from July 1, 1887, and are payable quarterly.

(1.) Statement of the General Account.

John Hamilton, Treasurer, in account with The Pennsylvania State College "General Account."

DR.

To semi-annual interest from State Treasurer, ...	$30,000 00
To proceeds of notes negotiated, ...	11,230 00
To amount received from students' fees, ...	6,963 39
To amount from sales off the College farm, ...	4,561 21
To amount received from Mechanic Arts Department, .	597 25
To interest from the State Treasurer on the proceeds of the sale of the Eastern and Western Experimental Farms, as per act of Legislature of 13 May, 1887, being 6 per cent. on $17,000 to October 1, 1888, . .	378 33
To amount received from the U. S. Experiment Station Account, due the College for various sums advanced by it to the Station, ...	1,267 69
To amount received from Geo. W. Hood, proceeds of the sale of the Western Experiment Farm, ...	7,000 00
To amount received from Dr. William Frear, balance in his hands of Eastern Experimental Farm money, . .	26 51
To damages from students, ...	206 21
To College building account, ...	244 28
To Cottage Planing Mill Co, ...	214 81
To sundry persons, ...	564 95
Total, ...	$63,254 63

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CR.

By balance due Treasurer, December 31, 1887,	$2,859 24	
By orders of the President of the College, paid,	60,394 87	
By balance on hand December 31, 1888,	52	
		$63,254 63
Balance in hands of Treasurer, December 31, 1888,		$0 52

(2.) State Appropriation Account.

Statement of receipts and expenditures from June 3, 1887, to December 31, 1888.

1887.	DR.	
Sept. 7.	To amount from State Treasurer,	$17,000 00
Dec. 16.	To amount from State Treasurer,	16,000 00
Dec. 16.	To amount for brick machine (returned),	157 50
1888.		
May 15.	To amount from State Treasurer,	24,000 00
Aug. 7.	To amount from sundry persons,	45 90
Oct. 16.	To amount from State Treasurer,	15,000 00
Oct. 16.	To amount material sold,	241 29
Dec. 8.	To amount from State Treasurer,	28,000 00
	Total,	$100,444 69

CR.—BY PAYMENTS MADE UPON ORDERS OF THE PRESIDENT OF THE COLLEGE.

ACCOUNTS.	1887.	1888.	Total.
Expense,	$34 01	$94 94	$128 95
Quarry,	1,155 94	335 65	1,491 59
Brick,	362 75	1,017 91	1,380 66
Chemical and Physical laboratory,	3,782 06	10,523 13	14,305 19
Botanical laboratory,	3,771 48	3,809 08	7,580 56
Armory,	.....	11,752 46	11,752 46
Dwelling houses,	363 61	6,808 75	7,172 36
Electric light,	4,067 44	1,656 27	5,723 71
Repairs (old),	3,755 95	1,185 86	4,941 81
Mechanic Arts, equipment,	2,266 85	1,543 82	3,810 67
Architect,	1,034 32	2,575 50	3,609 82
Chemical and Physical Laboratory, equipment,	105 53	874 73	980 26
Civil Engineering,	.....	626 33	626 33
College building (contract),	.....	4,495 65	4,495 65
Deficiency account,	.....	4,434 88	4,434 88
Furniture,	.....	286 01	286 01
Wages,	504 77	.....	504 77
Road extension,	123 15	.....	123 15
Wood and sand,	111 85	.....	111 85
Totals,	$21,439 71	$52,020 97	$73,460 68
Balance in hands of the Treasurer December 31, 1888,			26,984 01
			$100,444 69

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(3.) State Experiment Station Account.

December 31, 1888.

By direction of the Board of Trustees at their January meeting, 1888, the appropriation to this account was to be set aside for use in erecting an Experiment Station building. Some of the funds had already been used for other purposes, and this was ordered to be repaid out of the receipts from the "Hatch" fund when they should be realized. In 1887 the treasurer received from the State Treasurer under act of Legislature of June 3, 1887, ... $1,500 00
And paid out on orders of Geo. W. Atherton, President, . 1,235 63

Leaving a balance in his hands December 31, 1887, . . . $264 37
He received in 1888 from the State Treasurer, ... 3,750 00
From the Hatch fund, ... 1,924 95
Other sources, ... 64 25

Total, ... $6,003 57

He expended in 1888—

Sundry items for State, ...	$752 13	
Experiment station building, ...	4,885 86	
		5,637 99

Balance on hand December 31, 1888, ... $365 58

(4.) United States Experiment Station Account.

Under act of Congress known as the "Hatch Act," the College is permitted to use three thousand dollars out of the fifteen thousand dollars of the first year for building purposes, and thereafter seven hundred and fifty dollars annually to be applied to the same purpose. The Trustees directed that the three thousand dollars of the first year should be used in erecting an Agricultural Experiment Station building and that so much of the State Experiment Station fund as had been used for the running expenses of the station since July 1, 1887, should be refunded to that account out of the Hatch fund.

The treasurer received during the year as follows:

1888.

March 10, from the United States Treasury, ... $7,500 00
April 19, from the United States Treasury, ... 3,750 00
July 16, from the United States Treasury, ... 3,750 00
October 12, from the United States Treasury, ... 3,750 00

Total, ... $18,750 00

There was expended from this account on orders of the President of the College for the following purposes:

Insurance, ...	$51 00
Wages, ...	570 14

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Salaries,	$8,486 82	
Office expenses,	1,302 50	
General expenses,	748 61	
Live stock,	968 71	
Bills payable,	625 00	
Supplies and apparatus,	1,082 37	
Fertilizers,	68 36	
State Experiment Station (reimbursement),	1,924 05	
Pennsylvania State College (reimbursement),	226 17	
Experiment Station building,	2,961 21	
Director's house (heating),	250 00	
Unclassified,	103 90	
Total,		$19,369 74
Deduct receipts,		18,750 00
Balance due Treasurer December 31, 1888,		$619 74

The Board will notice that the proceeds of the sale of the Eastern Experimental Farm is not inclued in the statement of the "general" account, notwithstanding the order of the Board to have it paid into the College treasury and thence to the State Treasurer. This omission was caused by the refusal of the parties paying the money to deliver it to anyone except the State Treasurer and it was accordingly paid directly into the State treasury. The amount was $10,000, and this with the $7,000 received from the sale of the Western Experimental Farm gives the College an additional investment of $17,000, bearing six per cent. interest, or $1,020 each year to go to the "sole and exclusive purpose of maintaining a mechanical workshop and chemical laboratories, and of conducting educational and scientific experiments on the experimental farm located at the State College."

The Treasurer was uncertain as to the best method of keeping this account, but finally deposited the money in the general account in the College treasury. A statement is annually required to be made to the Governor of the Commonwealth of the receipts and disbursements of this account. Might it not be best therefore to keep it as a separate account and so prevent any confusion that might arise from mingling this interest with the general funds?

Respectfully submitted.

JOHN HAMILTON,
Treasurer of The Pennsylvania State College.

STATE COLLEGE, PA., *December 31, 1888.*

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16. REPORT OF THE BUILDING COMMITTEE OF THE PENNSYLVANIA STATE COLLEGE, DECEMBER, 31, 1888.

To the Board of Trustees of The Pennsylvania State College.

GENTLEMEN: The Committee appointed by the Board at their meeting in Janury, 1888, to take charge of the erection of the buildings and improvements authorized by Act of Legislature of June 3, 1887, respectfully report:

That they entered upon their duties immediately after their appointment, and have continued the oversight during the year. Previous to the appointment of the Committee the walls of the Botanical Laboratory were up and the roof on and floors laid, the greenhouse was in use although not finished. The foundations of the Chemical and Physical Laboratory were in to the height of the grade line. The foundation of one of the Professor's houses was built and the excavation made for the other. Stone sufficient to complete the foundations were on the ground. The Electric Light Plant was in use. Considerable general repairing had been done. Some brick had been made under contract, but of inferior quality owing chiefly to the character of the clay used, and were worthless. Your Committee were not bound by any contracts previously made except two: one for the foundations of the two dwellings and one for the manufacture of one million brick. An examination of the accounts showed that the Botanical Building would overrun its appropriation, and that the Chemical and Physical Laboratory as planned, could not be built for the money appropriated. It was accordingly determined to finish this building last and then modify it so as to bring it within the money at our disposal.

Some stone cutters, however, were kept at work during the winter preparing stone for the basement story above the grade line, and when enough for this purpose were out, the work was suspended.

It was also determined to let all future work by contract, and, accordingly, the architect was requested to get out the plans and specifications as quickly as possible, for the two dwellings and the Armory and Assembly Hall.

In the meantime your Committee compromised with the contractor, who had the making of the one million of brick, by which he surrendered his contract and left the Committee free from the embarrassment in this direction; his contract being objectionable in that it required the College to furnish wood, sand, sheds, etc., to the contractor, and also to provide a clay crusher for his use. It had become necessary also to change the location of the plant, as the clay was unsuitable in

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the location then occupied and the College was expected to bear the expense of the transfer. It was also thought, that a contractor who would assume the entire expense of the manufacture of the brick, and who would furnish all the material in the wall would be more desirable than to have several contractors, each doing a separate part of the work.

On the 23d of February, the following printed notice was sent to Bellefonte, Williamsport and Harrisburg papers for insertion, additional slips were enclosed directly to individuals known to be interested in contract work:

"*Sealed proposals* will be received at the office of F. L Olds, Supervising Architect of The Pennsylvania State College, at State College, Centre county, Pa, up to 12 M. on the 13th day of March, 1888, for the following work, to wit:

The furnishing of all materials, labor and completion of two dwellings constructed of brick and wood, the foundations for which are completed? Also, for an Armory and Assembly Hall, one-story building of brick or stone, ground size 81x160 feet.

Also, for the completion of the outside foundation walls of the Physical and Chemical Laboratory building. Drawings and specifications for the foregoing work can be seen at the office of the supervising architect.

Each bid to be accompanied with a certified check for one hundred and fifty dollars, made payable to the treasurer of The Pennsylvania State College. Said check to be returned if the bid is not accepted or, if accepted, to be returned upon signing the contract.

Bids to be addressed to John Hamilton, Chairman Building Committee, State College, Centre county, Pennsylvania. The right is reserved to reject any or all bids.

Plans and specifications for additional buildings are in preparation and will be advertised for proposals at an early date.

JOHN HAMILTON,
C. W. ROBERTS,
Committee."

In answer to this, five bids were received and opened by the Executive Committee of the Board on the 13th day of March. The bids were as follows:

C. W. Uhdy, Warren, Pa., armory and dwellings, $41,350; Plummer & Jeffries, West Chester, Pa., armory, $27,500, houses, $13,527; P. B. Crider & Son, Bellefonte, Pa., armory, $28,500, houses, $11,000; Hoover, Hughes & Co., Philipsburg, Pa., armory $22,744, houses, $8,262; Cottage Planing Mill Co., Huntingdon, Pa., armory, $18,511, houses, $8,190.

The bid of the Cottage Planing Mill Company on the Armory, being the lowest, was accepted, but their bid for the houses, although the

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lowest, was still above the amount of money at our disposal and a modification of the plans was ordered and another bid was received from the Cottage Planing Mill Company, on the 4th of April, offering to do the work for $6,250. This was accepted and agreements for the Armory and dwellings were made out and signed and work at once began.

Plans and specifications for an Experiment Station building or laboratory were prepared by the architect and, after due notice to contractors, two bids were received which were opened by the Executive Committee, April 13, 1888.

One from the Bedford Planing Mill Company proposed to do the work for $11,374. The other from the Cottage Planing Mill Company offered to do it for $10,930. This also was let to the Cottage Planing Mill Company of Huntingdon.

On the 13th of April, a bid was received from the Cottage Planing Mill Company for the completion of the Botanical Laboratory. The bid contained an itemized estimate and amounted to $1,202. This was accepted and the company authorized to go on with the work.

There remained the Chemical and Physical Laboratory to be provided for. About $21,000 of the thirty-five thousand appropriated for this building was left with which to complete it. Consequently considerable modification of the original plans was necessary in order to keep within the funds at our disposal.

The Committee had the architect complete the plans and specifications as modified, and after the approval of the change by the Executive Committee, advertised for bids. Printed slips were sent to all the previous bidders, and also to members of the Board to hand to any contractor that they might think desired to bid.

The following is a copy of the advertisment:

THE PENNSYLVANIA STATE COLLEGE,
STATE COLLEGE, CENTRE CO., PA., *June 18, 1888.*

To ——— ———:

DEAR SIR: Sealed proposals will be received on a brick and wood Chemical and Physical Laboratory building, eighty by one hundred and thirty, for the Pennsylvania State College, up to June 26, 12 M.

The foundations of this building are in, and the plans and specifications for the superstructure can be seen at the office of F. L. Olds, supervising architect, State College, Centre county, Pa.

All bids to be addressed to John Hamilton, Chairman of Building Committee, State College, Centre county, Pa.

JOHN HAMILTON,
CHAS. W. ROBERTS,
Committee.

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In response to this, two bids were received; one from Hoover, Hughes & Company, of Philipsburg, Pa., for $25,650, and the other from the Cottage Planing Mill Company, for $23,490.

At the same time a bid by the Cottage Planing Mill Company was received proposing to reconstruct the interior rear wing of the main College building and also to construct new stair-ways in the central portion of the building, in accordance with plans and specifications submitted, for the sum of $5,120.

These bids were submitted to the Board at its June meeting, and that of Cottage Planing Mill Company for the Chemical and Physical Laboratory was accepted, as also their bid for the improvement of the College building, but since there was only about $21,000 on hand for the completion of the Laboratory, it was agreed that the architect's salary for the next six months, one thousand dollars, also five per cent. of the contract price of the Experiment Station building and the Director's house, $706.50, should be added to the $21,000, together with about $500, the estimated saving in the dwellings and the other buildings, to make up the contract price, $23,490.

The appropriation account for repairs had left to its credit $4,338.70. To this amount the board added $800 out of the undistributed balance of the College appropriation account to make up the contractor's price of $5,120 for the repair of the College building.

The electric light plant had over-run its appropriation about $800, and it was also agreed that this amount should likewise be provided for from the unappropriated balance of the College appropriation account.

Everything had now been been provided for and all within the amount appropriated. Articles of agreement were drawn up and signed by the Cottage Planing Mill Company for all of this work, and on these contracts responsible bondsmen were required to guarantee the full performance of the agreements.

The specifications and plan of the Armory required the contractors to set the building fifteen inches above the grade line and the foundations were to extend three feet below. When the building was located it was found that the conformation of the surface of the ground was such as to require it to be placed higher in order to elevate it sufficiently to insure drainage from its walls as well as to add to its appearance from its approaches. The extra wall necessary to do this was of course outside of the contract and cost $984 additional. The floor of this building was to be of concrete, with double thick floor of boards on top. This necessitated the filling up of the interior with earth to the line of the concrete, and this was partly provided for in the contract for the Experiment Station building in which the contractor was required to convey all earth not needed for grading there to the Armory to fill the interior. About two thirds of the necessary filling was secured by this method and the balance was filled in by the Col-

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lege team. The arrangement being that the Building Committee would pay for the labor required and that the farm would furnish the teams free of charge. A large amount of grading about the armory was necessary, and this was partly provided for in the contract for the repair of the College building which required the contractor to remove all refuse mortar, brick, etc., and deposit it at the Armory. The balance of the grading was done by the Committee under the same arrangement with the College Farm as in the case of the filling of the interior.

The water was conducted to the armory from the mains above the College barn and sewer pipe sufficient to connect with the sewer at the engine house is on the ground. This building, by the terms of the contract, was to have been finished by October 1, 1888. It is not yet completed, although it is under roof and will be ready for use in a month or six weeks. The contractor gives as excuse that the brick could not be got out, owing to the unusually wet summer, which destroyed large quantities of brick in the yards and delayed the drying of others.

The sub-contractor who had the erecting of the iron roof trusses was delayed nearly two months by the falling of three of the five trusses, and their consequent damage requiring them to be returned to the shops at Uniontown to be repaired.

The tower is only partially up, but it is securely covered and can be completed early in the spring. The entire amount so far expended on the Armory is $11,752.46 and there is still due the contractor $8,229.78, making a total cost of $19,982.24, leaving $17.76 to its credit.

The two cottages, one for the military Professor and the other for the Director of the Experiment Station are finished, and are occupied by these officers. They were to have been completed by the first of August, 1888, but were not ready for the occupants until October 31, in case of the Director's house, and about a fortnight later in the case of the one for the military Professor.

The heating of these houses, the mantels and grates, the sewer pipes and cess-pools, and the hardware, such as locks, hinges, catches, hooks, etc., were not included in the contract. The Director's house is heated by steam at a cost of $450. By arrangement with the Director this cost was paid by the Experiment Station.

The military Professor's house is heated by a furnace at a cost of one hundred and twenty-eight dollars. The grounds around these dwellings have been graded, water pipes, cess-pool and sewer pipes were furnished by the Committee. The entire amount paid on these dwellings is $7,172.36, and there is still due the contractor $681.93, making the total cost $7,854.29, leaving a balance of this appropriation on hand of $145.71.

The Botanical Building is completed and has been in use since the opening of the fall term. The Committee were under the necessity of arranging for the heating of this building in order that it might be

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occupied, and exchanged a boiler that had been purchased in 1887, and intended for heating by hot water for a steam boiler, and contracted for the heating by steam—an additional chimney had to be built in the boiler house in order to accommodate the steam boiler. The entire cost of this building, not including the cost of quarrying and hauling the stone is $8,005.31, or $3,005.31 over its appropriation.

The Experiment Station building was, by order of the Board, not to exceed in cost $15,000, and this money was to be derived from the State experiment station appropriation and the Hatch fund.

The experiment station account to furnish, ...	$12,000 00
And the Hatch fund, ...	3,000 00
Making the total of, ...	$15,000 00

The contract price for this building was $10,930. The steam heating cost $950. The gas apparatus cost $1,075 and the furniture $1,110, making a total of $14,065. This does not include the bill for hardware such as locks, hinges, catches, drawer-pulls, etc.

There has been expended on this laboratory:

Out of the Hatch fund, ...	$2,961 21
Out of the State experiment station account, ...	4,885 86
	$7,857 07

It is expected that this building when completed will cost the entire amount appropriated, $15,000. The steam and gas are in and the furniture and cases are being set, and it is hoped that the building will be ready for occupancy in thirty days. The contract time for finishing it was November 1, 1888.

Provision will have to be made for raising the money necessary to pay the contractor on the completion of the work, and carry the amount over until the funds due from the State are received, a portion of it extending to June 18, 1891.

Some grading was done about this building, but only sufficient to protect the walls from surface water during the winter. A good deal of work in this direction will be necessary.

Work on the Chemical and Physical Laboratory was resumed in midsummer, and it is now under roof. It was evident in the autumn that it would be impossible to get it roofed in that fall, if additional brick were not secured outside of those made by the contractor on the ground. The contractor was urged to purchase the additional amount necessary to complete the building, and he arranged for 80,000, an amount sufficient to case the entire exterior walls of the structure. These were laid in white mortar, and were of much better quality than those made at the College. The cross walls in the interior were laid up of brick taken from those that came out of the College building, which the Committee agreed might be the property of the con

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tractor, and be used in this place. A large amount of grading had been done during the winter, and this fall considerable more was necessary in order to protect the foundations from injury by rain and frost. The contractor claims that he is entitled to an allowance for an additional amount of Ohio stone used by him on the first story, owing to the unsuitable size of that furnished by the College last year. He also claims an allowance for the white sand used in laying the outside brick, and also a bill for the extra weight of iron and additional amount of material used by him in the construction of the roof.

The contract requires in all cases where changes are made that the order shall be in writing, and no order was given by the Committee authorizing any departure from the plans and specifications as originally made out.

The contractor has until the 15th day of July, 1889, in which to complete this building. The contract does not include the heating, gas, plumbing, ventilating apparatus, or furniture, and funds will have to be provided for this purpose. The heating and lighting of the Armory will also have to be provided for outside of the appropriation.

There has been expended on the building, not counting the cost of quarrying the stone,	$14,305 19
There is yet due on the contract,	14,408 74
Making a total cost of	$28,713 93
The appropriation was	35,000 00
Thus saving,	$7,286 07
To this add amount saved in the houses,	145 71
Also cash proceeds of sales of material,	446 69
Also amount due from contracts for material,	367 10
Also amount due from the Experiment Station architect's salary,	706 50
	$8,952 07

In hand with which to meet the indebtedness contracted in 1887, and other expenses not included in the foregoing statement.

Botanical Building deficiency,	$3,000 00
General expenses,	128 95
Quarrying account,	1,491 59
Brick account,	1,380 66
Architect's salary for one year,	2,406 48
Wood and sand,	111 85
Total,	$8,519 53

Leaving a balance of the building fund expended after all is completed of $432.54.

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The Electric Light Plant, which was in use when the Building Committee was appointed, but was in some respects imperfect, and its account unsettled and which it was estimated would exceed its appropriation $800, making a total cost of $5,800, was inspected by an expert and changes and additions made that were important as affecting both the efficiency and safety of the plant. The Board appropriated, as has before been stated, $800, out of the unappropriated balance of the general college account, to meet this deficiency. Final settlement was made including the changes and additions mentioned, for $772, leaving $28 unexpended to go back into the unappropriated balance of college funds.

The Board also directed the Building Committee to make the repairs necessary to protect the Vice President's house from the damage occasioned by rain sinking into the interior and flooding the rooms. After consideration it was determined to have the old pointing removed and the exterior repointed with the best quality of Rosendale cement, also to take off the outside casings of the windows and refit them so as to exclude the rain. Two large windows were also set in the attic rooms to replace a similar number of small ones that failed to admit sufficient light. The chimneys were also ordered to be repaired so as to provide draught for the furnace and fire places, that were defective. This work was done at a cost of $272.71, and the amount taken out of the unappropriated balance of the college account in conformity with the order of the Board. The committee also had a new cess pool dug and the pipes changed into it to replace the old one that overflowed and threatened to breed disease. This improvement was outside of the instructions of the Board and was paid for out of the repair and improvement account of the general college funds.

Plans for the improvement of the main college building were presented at the June meeting to the Board, the cost, as per bid of the Cottage Planing Mill Company, to be $5,120. At the January meeting of the Board, the Professor of Civil Engineering of the College was, at the suggestion of the President, elected consulting engineer to the Building Committee, to see after the proper form, strength and construction of the trusses, etc., that might go into the various buildings. The plans for the improvement of the rear center wing of the college building, provided for the support of the third, fourth and fifth floors by means of trusses that were to go into partitions and leave the entire space below the third floor clear for use as a chapel. The Building Committee repeatedly called the attention of the architect and of the consulting engineer to the extreme importance of having these trusses sufficiently strong to make all entirely secure, and were assured that they were all right and would sustain a much greater load than would ever come upon them. After they were in place and the load of the three floors was on them they were discovered to

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be weak and unsafe and considerable settling of the floors was observed as a consequence of their condition. An examination of the trusses showed them to be giving way, and in order to prevent the catastrophe of the whole interior falling into the cellar it became necessary to shore up the entire interior from the first floor to the fifth. After careful computation and consideration, your committee come to the conclusion that no wooden trusses of size suited to the location could be constructed that would sustain with security, the incumbent load, and inasmuch as many human lives might be lost through failure to have this part of the construction secure, your committee concluded to introduce iron or steel supports instead of the wood.

With this in view the architect was sent to Pittsburgh to get the advice of reliable construction companies in the matter, and also secure bids for the form of iron or steel construction recommended.

All the designs were very expensive ranging from $4,200 to $6,300 dollars not including the placing of them in position. The forms suggested were for these and other reasons rejected. Your committee then prepared a plan which was submitted to experts in Pittsburgh and approved, and a contract was entered into with the Pennsylvania Construction Company of Pittsburgh, Pa., to make the supports and erect them in place for the sum of $2,350.

The contract was made on the 20th day of August, 1888, and it stated that the whole was to be shipped within two weeks and to be in place within one week after it was delivered at the college. The work on the repairs of this portion of the building had now to be suspended and in order that all might be in place at the time of the opening of the Fall session of the College, the date for the opening was changed from September 12th to the 19th. Instead however of the construction company fulfilling the contract and having the girders in place not later than the middle of September, they were not in place until the 13th day of November. It is hardly possible to exaggerate the inconvenience that the college suffered by this delay.

The failure of the original trusses to stand the strain has caused great expense in addition to the serious delay of the work. The bill of extras directly occasioned by this will reach between $3,200 and $3,500 dollars.

As the work progressed it became important to add things that were not foreseen. A large well hole was left in the main hall opening into the second floor. The underside of the stairways was lined with yellow pine instead of plaster. The fifth floor hall ceiling was raised to fourteen feet. The walls of all the central portion of the corridors and stairs was kalsomined. The wainscoting was painted and sanded. The top and bottom of the wainscoting was finished with cap and base. Transoms were introduced over doors, a new floor was laid in the first hall. Large windows were opened into the rooms adjoining the

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stairways. Extra partitions were placed to make suitable division of the rooms; new rooms were fitted up in the front of the central hall.

A well constructed and commodious water closet was constructed on the fourth floor; water pipes with hose connections were run through all the stories in the main hall. Black boards were made in all the recitations rooms. Electric lights were replaced. The steam heating had all to be changed in the rear wing. Recitations rooms were painted and the old walls covered with a coat of plaster to conform to the other sides which were new. Ceiling and papering and many minor matters, that could not have been anticipated, were done in order to make the job complete. These extra expenses will cost but $3,000 or $3,200 dollars more, making the total cost outside of the contract about $6,400 dollars. Only an inspection of the buildings will show what has been done, and itemized accounts of all are on file.

The halls and stairways are finished and the rooms above the chapel are nearly ready for the occupants. Another month will, it is believed, see it all completed.

Whilst the committee regret the outcome of the college building account, they nevertheless feel that they are not responsible for the error committed and could only go ahead after it was discovered.

All of the work done is secure and is as inexpensive as the circumstances and its importance would permit. Your committee are constrained to say, in concluding this lengthy report, that the entire work of the year has been under their constant supervision, so that they are confident that no serious defect in the construction of any of the buildings exists, and all bills, estimates and material have been carefully inspected.

Your committee have declined to make final settlement with the contractor in the matter of the construction of the two dwellings, and they desire instructions as to what they shall do in this and other cases that arise when the time for the completion of the buildings has expired and a forfeiture is liable.

The committee also desire instructions as to the settlement with the Pennsylvania Construction Company, of Pittsburg, in view of their failure to fulfil their contract.

Respectfully submitted.

JOHN HAMILTON,
CHARLES W. ROBERTS.
Committee.

December 31, 1888.

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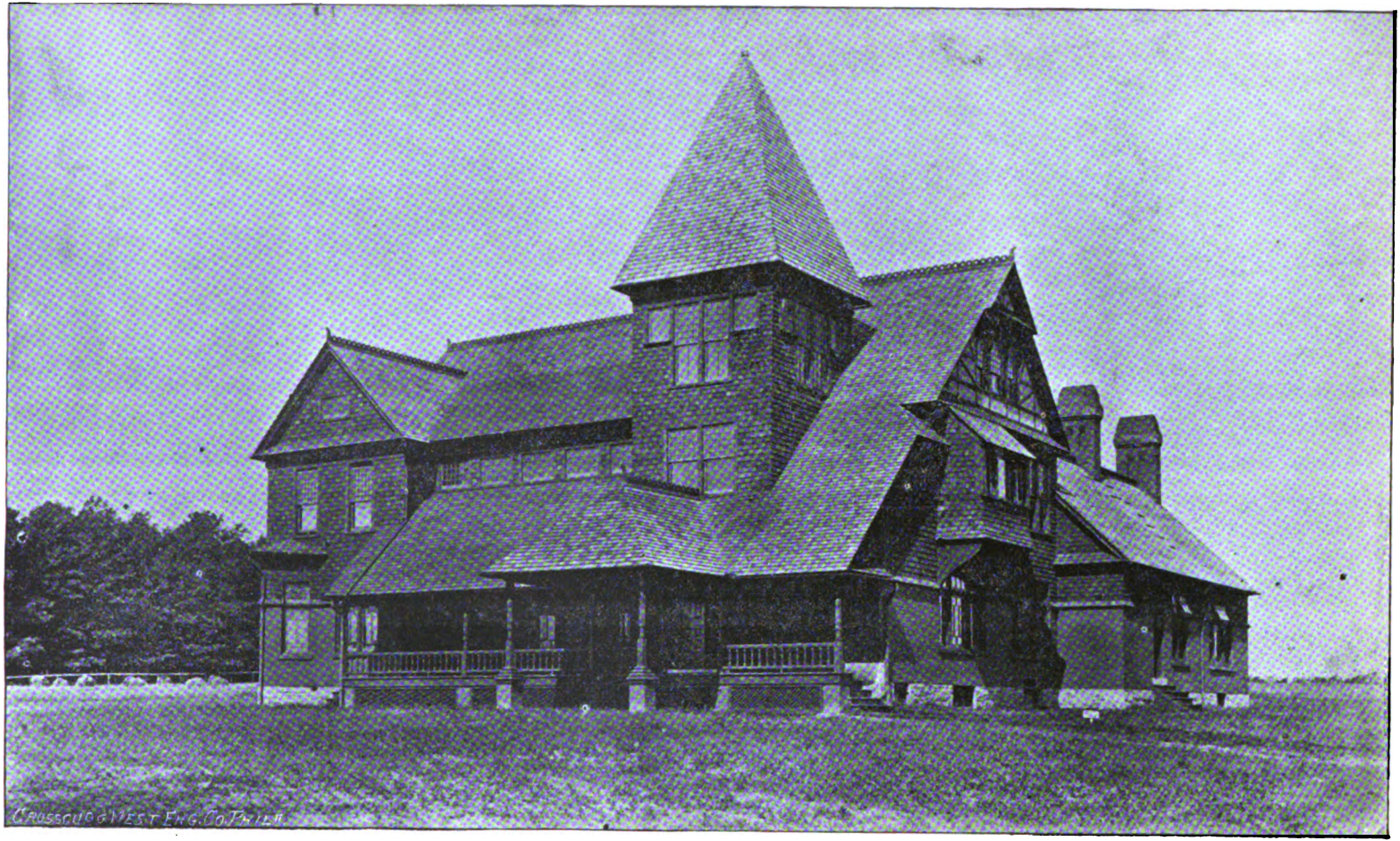

EXPERIMENT STATION.

OFFICE AND LABORATORY BUILDING.

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REPORT

OF THE

PENNSYLVANIA STATE COLLEGE

FOR THE

YEAR 1888

PART II.

Agricultural Experiment Station.

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The bulletins and annual reports of this Station will be sent free to all residents of the State who request it, as far as the supply will allow.

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STATE COLLEGE, PA., *January 30, 1889.*

GEO. W. ATHERTON, *L.L. D.*,

President, Pennsylvania State College :

DEAR SIR : I have the honor to present to you the enclosed report of the work of the Agricultural Experiment Station of the Pennsylvania State College for the year 1888.

Very respectfully,

H. P. ARMSBY,

Director.

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OFFICERS OF THE STATION FOR 1883.

THE PRESIDENT OF THE COLLEGE.

H. P. ARMSBY, Ph. D., ... Director.
WM. FREAR, Ph. D., ... Vice Director and Chemist.
WM. A. BUCKHOUT, M. S., ... Botanist.
GEO. C. BUTZ, M. S., ... Horticulturist.
WM. C. PATTERSON, ... Superintendent of Farm.

ASSISTANTS.

WM. H. CALDWELL, B. S., ... Assistant Agriculturist.
H. J. PATTERSON, B. S.,* . . . . . } Assistant Chemists.
GEO. L. HOLTER, B. S., ... }
W. S. SWEETSER, B. S., ... }
GEORGE OLLEY, ... Gardener.
MISS JULIA C. GRAY, ... Clerk and Stenographer.

Post-Office, ... State College, Centre county, Pa.
Railroad, Telegraph and Express Station, ... Lemont, Pa.

* To July 1, 1883.

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LAWS RELATING TO THE STATION.

[Act of Congress approved March 2, 1887. (The Hatch Act.)]

An act to establish agricultural experiment stations in connection with the colleges established in the several States under the provisions of an act approved July 2, 1862, and of the acts supplementary thereto.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That in order to aid in acquiring and diffusing among the people of the United States useful and practical information on subjects connected with agriculture, and to promote scientific investigation and experiment respecting the principles and applications of agricultural science, there shall be established, under direction of the college or colleges, or agricultural department of colleges, in each State or Territory established, or which may hereafter be established, in accordance with the provisions of an act approved July 2, 1862, entitled "An act donating public lands to the several States and Territories which may provide colleges for the benefit of agriculture and the mechanic arts," or any of the supplements to said act, a department to be known and designated as an "agricultural experiment station:" *Provided*, That in any State or Territory in which two such colleges have been or may be so established, the appropriation hereinafter made to such State or Territory shall be equally divided between such colleges, unless the Legislature of such state or Territory shall otherwise direct.

SECTION 2. That it shall be the object and duty of said experiment stations to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same; the chemical composition of useful plants at their different stages of growth; the comparative advantages of rotative cropping as pursued under a varying series of crops; the capacity of new plants or trees for acclimation; the analysis of soils and water; the chemical composition of manures, natural or artificial, with experiments designed to test their comparative effects on crops of different kinds; the adaptation and value of grasses and forage plants; the composition and digestibility of the different kinds of food for domestic animals; the scientific and economic questions involved in the production of butter and cheese; and such other researches or experiments bearing directly on the agricultural industry of the United States as may in each case be deemed advisable, having due regard to the varying conditions and needs of the respective States or Territories.

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SECTION 3. That in order to secure, as far as practicable, uniformity of methods and results in the work of said stations, it shall be the duty of the United States Commissioner of Agriculture to furnish forms, as far as practicable, for the tabulation of results of investigation or experiments; to indicate, from time to time, such lines of inquiry as to him shall seem most important, and, in general, to furnish such advice and assistance as will best promote the purposes of this act. It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the Governor of the State or Territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States.

SECTION 4. That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same, and as far as the means of the station will permit. Such bulletins or reports, and the annual reports of said stations, shall be transmitted in the mails of the United States free of charge for postage, under such regulations as the Postmaster General may from time to time prescribe.

SECTION 5. That for the purpose of paying the necessary expenses of conducting investigations and experiments and printing and distributing the results as hereinbefore prescribed, the sum of $15,000 is hereby appropriated to each State, to be specially provided for by Congress in the appropriations from year to year, and to each Territory entitled under the provisions of section eight of this act, out of any money in the treasury proceeding from the sales of public lands, to be paid in equal quarterly payments on the first day of January, April, July and October in each year, to the treasurer or officer duly appointed by the governing boards of said colleges to receive the same, the first payment to be made on the first day of October, 1887: *Provided, however*, That out of the first annual appropriation so received by any station an amount not exceeding one-fifth may be expended in the erection, enlargement, or repair of a building or buildings necessary for carrying on the work of such station, and thereafter an amount not exceeding five per centum of such annual appropriation may be so expended.

SECTION 6. That whenever it shall appear to the Secretary of the Treasury, from the annual statement of receipts and expenditures of any of said stations that a portion of the preceding annual appropriation remains unexpended, such amount shall be deducted from the next succeeding annual appropriation to such station, in order that the amount of money appropriated to any station shall not exceed the

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amount actually and necessarily required for its maintenance and support.

SECTION 7. That nothing in this act shall be construed to impair or modify the legal relation existing between any of the said colleges and the government of the States or Territories in which they are respectively located.

SECTION 8. That in States having colleges entitled under this section to the benefits of this act, and having also agricultural experiment stations established by law separate from said colleges, such States shall be authorized to apply such benefits to experiments at stations so established by such States, and in case any State shall have established, under the provisions of said act of July 2 aforesaid, an agricultural department or experiment station in connection with any university, college or institution not distinctively an agricultural college or school, and such State shall have established or shall hereafter establish a separate agricultural college or school, which shall have connected therewith an experimental farm or station, the Legislature of such State may apply in whole or in part the appropriation by this act made, to such separate agricultural college or school, and no Legislature shall by contract, expess or implied, disable itself from so doing.

SECTION 9. That the grants of moneys authorized by this act are made subject to the legislative assent of the several States and Territories to the purpose of said grants: *Provided*, That payments of such instalments of the appropriation herein made as shall become due to any State before the adjournment of the regular session of its Legislature meeting next after the passage of this act shall be made upon the assent of the Governor thereof duly certified to the Secretary of the Treasury.

SECTION 10. Nothing in this act shall be held or construed as binding the United States to continue any payments from the Treasury to any or all the States or institutions mentioned in this act, but Congress may at any time amend, suspend or repeal any or all of the provisions of this act.

APPROVED—March 2, 1887.

Extracts from Act of Legislature of Pennsylvania approved June 3, 1887.

[No. 223, Laws of Pennsylvania, Session of 1887.]

SECTION 1. *Be it enacted, &c.*, That the following sums be and hereby are specifically appropriated to the several objects hereinafter named, to be paid by the State Treasurer to the said trustees of the said Pennsylvania State College, out of any moneys in the Treasury not otherwise appropriated, to wit:

* * * * * * * * * * * * *

For the purpose of erecting two dwelling houses, one for the military

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instructor in said college, and one for the director of agricultural experiment work, the sum of eight thousand dollars.

* * * * * * * * * * * * *

SECTION 2. That there is hereby appropriated, as aforesaid, for the purpose of increasing, at said State college, the work of an Agricultural Experiment Station as now conducted there, and publishing for distribution among the farmers of the State, the results of such work, the sum of three thousand dollars, each year, for four years, to be paid as aforesaid, in equal quarterly payments, beginning on the first day of April, in the year one thousand eight hundred and eighty-seven.

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FINANCIAL STATEMENT.

THE PENNSYLVANIA STATE COLLEGE AGRICULTURAL EXPERIMANT STATION *in account with the United States appropriation, 1888.*

Dr.

To receipts from Treasurer of the United States, as per appropriation for year ending June 30, 1888, under act of Congress approved March 2, 1887, ...		$15,000 00

Cr.

June 30. By Salaries, ...	$7,032 48		
Office expenses, ...	528 39		
Printing, ...	1,080 74		
Live stock, ...	1,104 39		
Implements, ...	238 64		
Chemical laboratory, . . .	611 80		
Horticultural department, .	127 91		
Botanical, ...	151 64		
Field experiments, ...	241 85		
Fertilizers, ...	83 61		
Feed, ...	57 56		
Fences, ...	15 45		
Labor, ...	512 67		
Traveling, ...	76 53		
Expense, ...	104 44		
Buildings, ...	2,996 35		
Repairs and improvements,	3 50		
		$14,967 95	
Balance unexpended, ...			$32 05

We, the undersigned, a committee appointed by the Board of Trustees to audit the accounts of the Agricultural Experiment Station of the Pennsylvania State College, do hereby certify that we have examined the books and accounts of said Station for the fiscal year ending June 30, 1888; that we have found the same well kept and correctly classified as above, and that the receipts from the Treasurer of the United States for the time named are shown to have been $15,000, and the corresponding disbursements $14,967.95, for all of which proper vouchers are on file and have been by us examined

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and found correct, thus leaving an unexpended balance of $32.05 to be accounted for in the fiscal year commencing July 1, 1888.

H. V. WHITE,
CYRUS GORDON,
Auditing Committe of Board of Trustees.

January 22, 1889.

I hereby certify that the foregoing statement is a true copy from the books of account of the Agricultural Experiment Station of the Pennsylvania State College.

JOHN HAMILTON,
Treasurer.

February 1, 1889.

I hereby certify that John Hamilton is the treasurer of the Pennsylvania State College, and that the above is his signature.

[SEAL.] GEO. W. ATHERTON,
President Pennsylvania State College.

February 1, 1889.

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REPORT OF THE DIRECTOR.

As noted in my report for 1887, I was not able to assume personal charge of the work of the Station until the close of that year. While the experimental work proper to a station has been actively carried on and considerably extended in scope since that date, a large portion of my time has necessarily been devoted to questions of organization and equipment. The large increase in the funds available for experimental work in agriculture, and especially the terms of the so-called "Hatch Act," donating the college $15,000 annually from the treasury of the United States, made necessary a more complete organization of this department of the college, and a separation of it in certain particulars from the other departments, corresponding to the difference in the character of its work.

Accounts.—In order to meet these new conditions, so far as they affected the finances of the Station, the board voted, June 30, 1887, "That the work in agricultural experiment and investigation carried on at and in connection with the Central Experimental Farm be hereafter conducted under the title of 'The State College Experiment Station,' and that the books of account be kept accordingly." In pursuance of this resolution a separate set of books was opened for the accounts of the Experiment Station, and early in the present year the keeping of these books was, by vote of the Executive Committee, transferred to the Director of the Station. From that time until June 30 the books were kept upon substantially the system previously adopted. In view of the fact, however, that the Station has to account both to the United States treasury for expenditures under the "Hatch Act," and to the State of Pennsylvania for expenditures from the appropriation made by the State, it was felt that our system of bookkeeping should be modified so that the books should show separately upon their face the expenditures from each of these funds as well as from the funds coming from sales of farm produce. A system of accounts was therefore adopted on July 1, 1888, with the approval of the Executive Committee, by which the books will show each of these three classes of expenditures by itself, and will also show separately the cost of the labor expended under any given account.

Officers of the station.—At the beginning of the year the officers of the station were as follows:

Geo. W. Atherton, LL. D., President of the College; H. P. Armsby, Ph. D., Director; William Frear, Ph. D., Vice-Director and Chemist;

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Wm. A. Buckout, M. S., Botanist; Geo. C. Butz, M. S., Horticulturist; Wm. C. Patterson, Superintendent of Farm; H. J. Patterson, B. S., Assistant Chemist.

During the year the following additions have been made: Geo. L. Holter and W. S. Sweetser, Assistant Chemists; Wm. H. Caldwell, Assistant Agriculturist; Miss Julia C. Gray, Clerk and Stenographer; George Olley, Gardener. Mr. H. J. Patterson, who for the preceding two and one-half years has had immediate charge of the chemical work of the Station, resigned on July 1 to accept the position of Chemist of the Maryland Agricultural Experiment Station, his place here being taken by Mr. Holter.

New Building.—One of the first needs of the Station under the new conditions was adequate office and laboratory accommodations, the old quarters in the college building being too small for its needs, and the room being urgently needed by the College for other purposes. It was therefore voted by the Trustees, January 24, to proceed with the erection of a building expressly for the accommodation of the Experiment Station at a cost not to exceed $15,000. After consultation with the other officers of the Station, and an inspection of the new building of the Massachusetts State Experiment Station, a plan for such new building was submitted to the building committee and adopted by them without material change. A brief description of the building, with cuts showing the floor plans and two elevations, was furnished by request to the September number of *Agricultural Science*, and is reproduced on subsequent pages of this report. The corner-stone of the building was laid, with appropriate ceremonies, June 27, 1888, and it is now approaching completion. In the meantime the Station has occupied temporary quarters in the college building at the cost of much inconvenience to itself and even greater inconvenience to the College.

Character of Station Work.—The Station proposes to undertake, in the interest of the farmers of the State, essentially three kinds of work:

First.—It will plan and carry out experiments designed either to add to our knowledge of the principles involved in the successful production of crops and animals or to show the best methods of applying in practice principles already established. This field of work, in both its sub-divisions, it regards as its most important one, and expects to make its most prominent one. Of the many problems which arise in the experience of every thinking farmer, it will select such as seem to be of most immediate practical importance to the farmers, gardeners and stock raisers of the State, and bring to bear upon their study all the resources both of practice and of science which it can command.

It does not expect to confine itself in this branch of its work exclusively or even largely to purely scientific experiments, that is experiments designed to establish principles. It will rather regard it as its chief duty to apply scientific methods to the study of practical ques-

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tions, that is, questions of practice as distinguished from questions of science, and while desiring to emphasize the importance and value of scientific research, and endeavoring to do so much of it as it deems consistent with its other duties, it will consider that its first obligation is to inform the farmers of the State upon those points on which they desire information.

Second. In addition to this work of general interest to all farmers, special questions often arise, of peculiar interest to one or a few farmers such as the value of some new kind of fodder, the purity and germinative power of a lot of seed offered or purchased, the name and value of a new grass or other plant, the name and habits of a new insect, etc., etc. The station will endeavor to the extent of its power to aid farmers by examining specimens of the various farm products, fodders, etc., sent to it, identifying plants, grasses, weeds, insects, testing seeds, etc., etc. In short all work proper to an Agricultural Experiment Station will be performed free of charge so far as it is for the general use and advantage of citizens of Pennsylvania. On the other hand, the Station cannot undertake private work, and it will make no examination the results of which it is not at liberty to publish or otherwise use at its discretion for the public good. Particulars as to the conditions upon which such samples will be examined, and directions for taking and sending samples will be found at the end of this report. These directions will also be mailed free on application.

Third. The Station will aim to make itself useful as a bureau of information on agricultural matters for farmers and others interested in its work, and will to the extent of its ability answer any inquiries pertaining to agriculture or horticulture. While it cannot assume to be able to answer satisfactorily all questions, all correspondents may feel sure that their letters will receive careful attention and as full a reply as possible.

Work of the past year.—The system of field experiments which had been carried on for several years upon the Central Experimental Farm has been continued without material change during the past year. Full meteorological observations have also been continued during the year. In connection with this work, arrangements were made early in the season by which the Station receives the daily weather indications sent out by the United States Signal Service, and displays them in the customary manner by means of flags from the tower of the college building.

In considering what additional work should be undertaken by the Station, I have been impressed with the importance of doing whatever is practicable towards developing the live stock industries of the State, not only on account of the direct profits which might thus be gained by farmers, but even more on account of the indirect benefits arising from the conservation and increase of the fertility

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of the soil consequent upon stock raising and feeding. Considerable work has, therefore, been done upon feeding problems, and more is projected and partly in process of execution. In this work it is proposed to pay particular attention to questions bearing on the economy of feeding and to endeavor to furnish some aid to the farmers of the State in reducing the cost of production of meat and dairy products. For details of the work already done, see the reports of experiments on subsequent pages.

Publications.—In order to bring its results before the public the Station publishes an annual report and bulletins at least quarterly. Under the provisions of the Hatch Act, these publications may be sent in the mails free of charge of postage. On the other hand, the Station is obliged at present to bear the entire expense of publishing its bulletins, and also the cost of printing, all above a certain limited number of reports. For these reasons it is not able at present to distribute them as freely as it would be glad to, but so long as the supply lasts they will be sent free of charge to all residents of the State who request it.

As required by the Hatch Act, the Station has published four bulletins during the past year:

No. 2, published in January, on Field Experiments with Phosphates.

No. 3, Published in April, on Composition and Digestibility of Corn Stover.

No. 4, published in July, on Seed Germinations.

No. 5, published in October, on The Digestibility of Soiling Rye.

A small pamphlet was also printed in August, entitled "List of Experiments in Progress." This was not sent out as a bulletin, but was distributed in connection with an exhibit of the work of the Station made at the Williams' Grove Grange Picnic, and at the State Fair in Philadelphia. The mailing list of the Station has experienced a moderate increase during the year, and now contains over 11,000 names.

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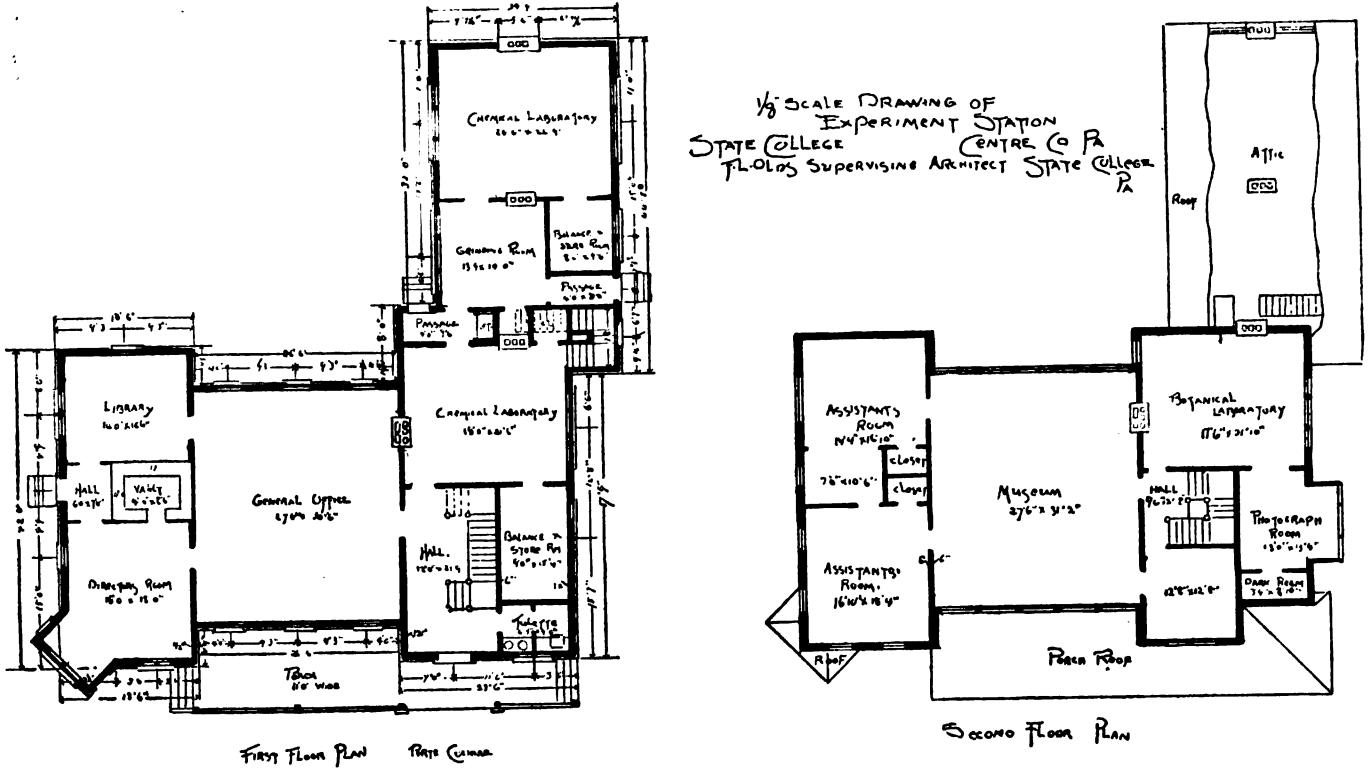

FLOOR PLANS OF OFFICE AND LABORATORY BUILDING.

PLATE I

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THE NEW BUILDING OF THE PENNSYLVANIA STATE COLLEGE AGRICULTURAL EXPERIMENT STATION.

BY H. P. ARMSBY.

The following description of this building is reproduced from "Agricultural Science" for September, 1888:

The building is designed to furnish office and laboratory accommodations, together with lodging rooms for asssistants. It consists of a main portion 68-6 x 42 in extreme dimensions, and two stories high, with an additional story in the tower over the main entrance, and of a one-story wing 44-8 x 24-9, placed at right angles with the main portion of the building. It is located in a commanding position, facing to the southeast, and affording an extensive view of the surrounding country, The main entrance hall 12 x 21-9, is located at the east corner of the building. On the left of this hall is the general office, 27-6 x 30-6, lighted by three windows on each side. It is the intention to put in permanent book-shelves in such a way as to make an alcove opposite each of these windows, thus affording to the officers of the station a convenient place for keeping such portions of their private libraries as they choose to deposit in the Station building, and giving them also a certain degree of privacy in their office work. In the center of the office will be located a table for general use. Provision is made for ventilating this room through a special flue placed in the same stack with the flue used for the heater.

Opening from the general office is the library, 14 x 16-6, and a director's room, 16-6 x 18, the two being connected by a small passage. Between the two is located a fire-proof vault, opening from the director's room, for the safe keeping of records, account books, documents, etc.

The main entrance hall also gives access to a chemical laboratory, 18 x 21-6, from which opens a balance and store room, 9 x 15-4. This latter room will be used both as a balance room and to store a sufficient supply of apparatus for the current use of the laboratory. A staircase leads from this room to the attic of the one-story wing, and also to a main store room for apparatus, located in the cellar underneath the laboratory, and accessible from outside the building. A hand-lift runs from this general store room to the attic of the wing. Passing into the wing across the passage in which the lift is located, and which serves also as an entrance, we come to the grinding-room, 18-9 x 14, which may also be entered by a passage from outside the building. Here the preparation of re-agents, the drying and grinding of samples for analysis, and similar work will be carried on. The vacant space

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next to the chimney-stack shown upon the plan will be occupied by the drying closet, heated by steam. In the extreme end of the wing, and entered through the grinding-room, is a second chemical laboratory, 20x22·9, with a balance and store room 8·6x9·6, opening from it. Both this balance room and the one previously mentioned have northeast light, and are thus protected from direct sunlight during nearly the whole day.

The ventilation of the laboratories and grinding-room is provided for by four chimney-stacks, each containing three flues. An attic, as already noted, extends over the whole wing and may be reached by a staircase from one of the laboratories, and also by the lift. Upon the second floor, the main entrance hall gives access to a museum-room, 27·6x31·2, located over the general office, and lighted upon each of two sides by five windows situated about five and a half feet above the floor. From the museum open two assistant's rooms, and a small room in the tower which may be used as a store room in connection with the museum.

Opening also from the main hall is the botanical laboratory, 18·6x21·10, and from this again opens a photograph room, 13x13·4, provided with a sky-light and a dark room. There is also a small room in the third story of the tower and an attic over the whole main portion of the building.

The cellar extends under the main portion of the building, and contains as already noted, a large store-room for apparatus, and also a gas analysis room, located under and of the same size, as the balance-room. Along the front of the building runs a porch eleven feet wide by fifty feet long, with a *porte cochere* opposite the main entrance.

The building above the foundations is of wood, brick-cased up to the transoms of the first story windows and shingled above that point.

The interior will be finished in first quality white pine, finished in the natural wood, with southern yellow pine floors throughout the building. It will be heated by steam, and gas will be furnished from a naphtha gas machine.

The corner-stone of the building was laid June 27, 1888, the following being the order of exercises:

Music.

Invocation.

Address, by Professor I. P. Roberts, Director of Cornell University Experiment Station.

Outline of Station Work, by Dr. H. P. Armsby, Director.

Music.

Address, by His Excellency, James A. Beaver, Governor of the Commonwealth.

Laying of Corner-stone, by Hon. Francis Jordan, President of the Board of Trustees.

Benediction.

Music.

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The following was Professor Roberts' address:

ADDRESS OF PROF. I. P. ROBERTS.

You do me greater honor than I deserve by inviting me to speak to you to-day, as you place the keystone in the great arch of experiment stations, maintained by our government. These stations are founded in order that light and knowledge may be sown so abundantly that the poorest toiler, the smallest farmer, may, if he will, have opportunity placed within his reach, and if he so desires, may make advancement in the art and science of agriculture.

One nation in all the ages since the world began has at last learned that it is wiser and cheaper to teach the weak how to get a living than to destroy them; that it is more noble to use the plow than the sword, and that the art of producing the comforts and luxuries of life is as far above the art of destroying them as heaven is above hell.

America is the first nation to teach the world that work is more respectable than idleness and that honor and dignity come from knowledge and training, and not from birth or calling.

The despised hind of Europe has here in this western world been transformed, as by magic, into the intelligent land holder, and his progeny educated to fill with credit every position of trust and honor in the land.

What forces, what causes, what influences have produced these latter-day miracles? Briefly stated that they are the legitimate product of knowledge. Our forefathers began by erecting a great experiment station. Its farm reached from ocean to ocean, from the snows of Canada to the everglades of Florida. Having secured the farm they began with great zeal and wisdom to lay corner-stones, or corner-logs, of experiment station buildings. A district school house arose on every four corners, a church in every grove, an academy by every babbling brook and a college by every lake side. And this for what? To train the sons and daughters of the hinds of Europe. To educate for mothers of statesmen, for teachers of youths, the daughters of Celtic sun-burned women who, in their own country, had carried the hod, cleaved the wood and tilled the soil.

In all the history of the world can there be found an example of an experiment so broad, so grand, so philanthropic and so likely to fail? Nominally we have met to lay the corner-stone of a building; but in fact we are here to place, with appropriate ceremonies, the capital upon the great educational column, the corner-stones of which were wisely laid and firmly cemented by the toil and sacrifice of our ancestors.

The structure to be erected upon these solid foundations we call an experiment station building. The name is long enough but not broad enough. It is a great public school building, an agricultural college with a million non-resident pupils. It is a new departure, not meant

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to supplant, but to supplement other educational institutions. It emphasises more emphatically than has ever been done before the fact that knowledge is power, that mind controls matter, that the forces of nature are unlimited, that man is the end, and that all else are but means. Every brick in this noble structure repeats again the God-given right "Man is to have dominion." This gift from our Creator apparently so free is hedged in by conditions, and these must be removed or we cannot enter into our inheritance.

"He that will not plow by reason of the cold shall beg in harvest and have nothing;" or we might render it—he that will not put forth energy, and toil with mind and body even to weariness in the spring-time of life shall gather no fruit in the autumn—shall not have dominion.

"I went by the field of the slothful and by the vineyard of the man void of understanding, and lo! it was all grown over with thorns, and nettles had covered the face thereof and the stone wall thereof was broken down. Then I saw and considered it well; I looked upon it and received instruction."

It appears that three thousand years ago there were men living who would have been benefited by an experiment station, for they did not know their business; they were void of understanding. These of whom Solomon speaks, were they, who, in their day and generation, held down the dry goods boxes at the corner groceries and whittled away at the old, greasy plank-bottomed chairs that leaned and squeaked out their brief existence on the front porches of the village hotels of Palestine. "The stone wall thereof was broken down:" with this brief information, how easily we can complete the picture.. The children of these men void of understanding have been routed out betimes, they have passed through the broken place in the wall and with naked limbs they are gleaning as best they may, the few half-dried fruits that are scattered here and there among the thorns and nettles.

It is high noon; an old unwashed man is entering Jerusalem at the fish gate; in either hand is a basket, one containing a dozen eggs, gathered by his wife, the other the children's gleanings. The fierce tropical sun has passed to the west till its rays strike squarely against the roof of the shadeless farmhouse, where toils the tired mother, who has no hope and yet must wait and toil and save. She may not even leave the house, for the only visible means of support is in the little patch of edibles just behind the stable, where still lingers a fraction of the neglected and wasted manures, and at any unguarded moment the razor-backed hog or the gothic cow may come through the broken wall thereof.

This man was not a "book farmer;" he did not believe in experiment stations; he was too indolent to find out what other people had learned before him, and too lazy to think. He was "void of under-

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standing," and if there had been poorhouses and colleges in those days, he would quite as soon have seen his children go to one as the other.

Doubtless my hearers have already divined my object in presenting this picture of thirty centuries ago. As I travel over this beautiful free country I see many fields—not all, thank Heaven—where thorns and nettles, or, more accurately speaking, thistles and daisies, ragweed and dock, cover the face thereof. I pass no judgement, but leave it with you to say whether the people who own these once fertile fields are void of understanding; whether they need an experiment station. We are a race of plant killers and sometimes so void of understanding are we, that we make room for the inferior by killing the superior plants. Through countless ages all of nature's forces have toiled unceasingly to prepare an earthly habitation for man. First the bowels of the earth were filled with a wealth of useful products, then the unending mighty forces began the work of preparing and adorning the surface of the globe. The little lichens and mosses, sent their tiny rootlets into the frost-made crevices of the barren rocks and forced them to yield their treasures of plant food to larger and more useful vegetation. The rocks, too hard for the plants to break, were ground and pulverized by the icy millstones of the winter-king. The beetle, the microbe and the bacterium, attacked all life, both animal and vegetable, the moment the highest conditions of existence were not maintained, and they in turn, gave their lives to enrich the soil, in order that more complex life might be developed. The soil builders toiled on and on until the earth was filled with fruitful vines and lofty trees, with tender grasses and vernal flowers. Myriads of noble animals cropped the tender herbage and drank the sparkling waters wherein countless fishes laved their glistening sides. Happy birds sang and mated and reared their young in the overhanging branches. These and those that preceded them, all happy, busy builders, were all content to give up their lives at the appointed time in order that the earth might be richer.

These forms used the same elements that man uses to maintain life. The particle of potash that the plant took from the rock to maintain its life was not wasted or lost, simply made more useful. The worm lived upon the plant, used the same elements to maintain its life, then died and returned to the soil, all its elements improved in quality and not diminished in quantity.

Now that the earth is fitted for the habitation of a nobler animal, man, the Lord of creation appears upon the scene. In one hand he bears the axe, in the other the fire brand. The old oaks, the product of centuries, shrink, tremble, and fall before the stroke of this intellectual animal. The tooth of time gnaws the gnarly, knotty oaks too slowly, and so the fire-brand is let loose and the work of destruction becomes complete. But provident nature has provided countless

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hitherto dormant seeds which now spring into life, and the battle begins. Nature, on one side trying to reclothe the earth and repair the breach; man, on the other, steadily advancing westward and up the steep mountain slopes to their summits, down over the river and through the valley and on and over till the axe has no more forest to conquer and the torch is quenched in the waters of the Pacific.

This has been the battle of the ages. We are not to repine or complain because serious mistakes have been made by our ancestors; rather remember their sterling virtues, give thanks for the rich inheritance bequeathed to us and gird the loins of our understanding that we may intelligently battle with the questions of the hour.

How to profitably till the soil so that it may minister to the higher as well as the lower wants of man; how to improve quality; how to increase productive power. These are the questions of the hour.

Agriculture consists in taking from the soil such concentrated elements of life as the world wants, and in replacing these elements with crude, cheap and waste products so skillfully that no serious diminution of fertility shall occur. The man void of understanding cannot do this. Skill, training, knowledge and labor are all required, and where either is notably deficient, the land and worst of all the land owner suffer. We have lost our inheritance through ignorance and indolence. We do not have dominion. The drouth dries up the corn on the hillside, the floods devastate the wheat in the valley. The cold dehorns the cattle of the plains and bacteria destroy the unborn young of the dairy. The caterpillar and the canker worm attack the leaf, the codling moth and the curculio the fruit, and the round-headed and the flat-headed and the larva with no head, the root and the branch. If we pluck a rose or a snow ball we are compelled to sympathise with Pharoah. Our best garment furnishes food for the moth; and all unwillingly, we feed the *Anthrenus Scrofulariae* on brussels and tapestry carpets. We toil and spin in summer's heat and winter's cold in order that we may have a surplus, and then with scarce a thought annually draw our check for twenty millions to pay the board bill of the cotton-worm; while the proud State of Illinois pays two and three-eighth millions for the work of the codling moth; and how many millions we annually pay for the board bills of the *Hymenoptera*, *Lepidoptera*, *Coleoptera*, *Hemiptera*, *Orthoptera* and the *Omnipresentoptera*, no man living can tell.

The scepter has departed from our hand. Shall we make a united and intelligent effort to gain dominion? That we have lost dominion no one can deny; for every day we go by the orchard of the man void of understanding, and lo! the codling moth has taken snap judgment thereon; and by the fields of the slothful man and wild carrots and stones cover the face thereof, and the owner thereof is broken down. Shall we consider it well and receive instruction? Can we guide and control these energies which have been building through the

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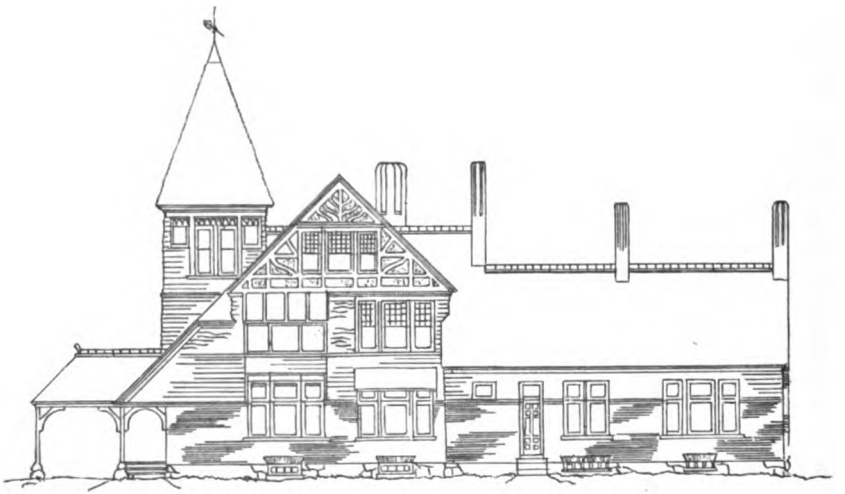

ELEVATIONS OF OFFICE AND LABORATORY BUILDING.

PLATE 2

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ages? Can we restrain within limits the teeming life of earth and air? Can we put our hand upon it and say thus far shalt thou come and no farther; make room; give place for a higher, a noble life?

Can we enforce obedience to our command when we say to the dull clods of the earth, "Yield up thy precious treasures, though thou hast refined them with fire and hidden them in thy secret chambers through ages?"

A nation with one united voice has answered, "Yes! Yes!" and before the echo of the answer dies away we meet to inquire, "How?" These stones and bricks will not answer. These beautiful fields and woods have kept their secrets through long ages; they will not yield them willingly. These babbling, singing brooks say, "Our song is hard to learn!" All nature's forces proclaim, all life speaks and says, "We were created by infinite wisdom and knowledge and we will not transgress the laws of our existence and yield up our secrets to the slothful and the ignorant. A power as great as that which created us must be possessed by him who would win our choicest treasures." *That power is knowlege.*

If the secrets of the earth are to be revealed unto men, men must be God-like.

Then the work of these stations devoted to searching out knowledge is to be good. It is not quantity but quality that we want. This station is to guard the people against fraud, adulteration and false balances as well as to search out improved methods and new principles.

This station is not to perform miracles but it is to do a greater work—reveal truth. It cannot make the careless read or heed, but it can help the man who is searching for the truth as for "hid" treasure. It cannot reveal all the secrets of the earth and air, but can give help and guidance to the inquiring mind.

It cannot speak into existence matter, but it can create thought.

We have prayed long and loud for the Gods to come down and help us and they have failed us; and now with hope that shall not be disappointed, and courage undaunted by adversity, we put our willing hands to the work of helping men, in order that they may recover their dominion of the earth.

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TESTS OF VARIETIES, 1888.

WM. H. CALDWELL.

CORN.

An experiment was carried on during the season of 1888 at this Station with a view to studying the adaptability of some varieties of field corn to this section, and also to make observations upon the yield of the corn plant at different stages of its growth. The land selected for the trial was old sod, which was laid off into plots each one-twentieth of an acre in area. No fertilizer was used. It was not the purpose to secure heavy yields, but rather to give each variety as equal a chance as possible under similar treatment.

The following varieties were planted:

For Ensilage or Fodder.

Breck's Boston Market Ensilage.—"It is the result of careful selection of seed to the end that a variety of corn might be obtained not to be grown for the crop of corn, but for the crop of green fodder."

Blount's Prolific.—A half Dent variety, remarkably prolific.

Dents.

Chester County Mammoth.—On rich land in the southern part of Pennsylvania and southward is said to be one of the best varieties of yellow field corn.

Golden Beauty.—Matures early and is very productive.

Golden Dent.—Ripens early. Cobs short and slender. Kernels long and yellow.

Mammoth White Surprise.—Especially adapted to Pennsylvania and south.

Pride of the North.—A standard variety for the north, ripening with the Flints.

Smedley.—A very productive, yellow Dent, maturing a little earlier than the Pride of the North.

White Giant Normandy.—A large variety.

Flints.

Self-Husking.—One of the earliest field corns in existence. Has a dwarf habit. Ears are large with small cob and amber grain; named from its inclination to strip itself clean of its husks.

Thorburn's Golden Yellow.—Raised in the north.

Tuscarora.—Large eight rowed white variety.

The seed of Breck's Boston Market Ensilage, Golden Beauty (1627), and White Giant Normandy, were sent by the United States Depart-

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ment of Agriculture. That of the Golden Beauty (1629), and Mammoth White Surprise, was obtained of Peter Henderson & Co., New York city. J. M. Thorburn & Co. furnished that of Thorburn's Golden Yellow. That of the others was purchased of H. Sibley & Co., Rochester, N. Y.

With the exception of Thorburn's Golden Yellow, all germinated well. This variety was planted twice, and each time failed to appear above ground. A germination test * showed that only six per cent. of the seed sprouted. During the night of September 1, several of the varieties were somewhat injured by loose cattle which accounts for the incomplete results given them in the tables.

PLAN OF THE EXPERIMENTS.

Samples for chemical analysis were taken at four different stages of growth:

1. When fully tasseled.
2. Ears beginning to fill out.
3. Kernels beginning to glaze.
4. Fully ripe.

The date of taking these samples was governed in each case by the development of the corn, the samples of the several varieties being taken as nearly as possible at the same stage of growth. In the first stage one of the middle rows was cut close to the ground, immediately weighed, and run through the fodder cutter. It was then thoroughly mixed and a sample selected from the various portions of the pile, care being taken to have it represent as nearly as possible the average of the whole. This was passed through a chopper in order to be in better condition for laboratory work. In each case the record of the number of hills in the row and their average height was taken. The outside row farthest from the row used for the first sample was taken in the second stage and treated in the same manner. The sample of the third stage was handled in a similar way, the rows between those taken for the first two samples being used. The fourth or remaining row was allowed to ripen, when it was cut and field cured. Its total weight was then taken, the ears husked, and the stover separated into three parts, namely, leaves and husks, upper half of stalks, and lower half of stalks. and these weighed separately. Six average ears were taken as a sample of the corn. Each portion of the stover was sampled in the manner previously spoken of. The chemical work was done by Messrs. Holter and Sweetser, the Station's assistant chemists. The analyses were delayed by other work and the lack of facilities, so that only the results of the dry matter determinations are used in this bulletin.

* Pennsylvania State College Agricultural Experiment Station.—Bulletin Number 4.

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YIELD PER ACRE.

In the following table will be found the yield of green material at the first three stages of growth mentioned and the total yield of field-cured material. The table shows the corrected and not actual yield per acre. A full row on each plot contained fifty hills. As some of the hills in many of the rows had been injured or failed to grow, fifty hills were taken as the unit, and it has been assumed that had the missing hills been present their yield would have been the same as the average of those which actually did grow. Thus if a row contained forty hills instead of fifty the actual yield observed has been increased by one-fourth in the table. While it is highly probable that this correction is somewhat too large, it is believed that the corrected results are nearer the truth than the actual yields, as the variation in the number of hills was considerable. It is to be remembered, also, that the results in the table were really obtained on one-eightieth acre plots, and that, therefore, any error is multiplied by eighty. Consequently it is plain that there is a considerable possible error involved and that *small* differences of yield have no significance whatever.

Corrected Yield Per Acre.

Station No.	Name.	Green Material.			Mature Field Cured.	
		Fully tasseled.	Ears beginning to fill out.	Kernels beginning to glaze.	Ears.	Stover.
	Ensilage or fodder.					
1751,	Breck's Boston Market Ensilage,	12,431	11,760	25,710	3,920	9,600
1686,	Blount's Prolific,	20,740	33,000	28,800	4,076	9,846
	Dents.					
1690,	Chester County Mammoth,	26,670	32,250	32,620	5,098	10,670
1627,	Golden Beauty (U. S. Dep't of Agriculture),	19,020	28,000	29,210	5,272	10,000
1629,	Golden Beauty (P. Henderson & Co.),	20.460	24,490	34,220	5,840	12,020
1689,	Golden Dent,	21,300	26,670	30,950	4,690	10,590
1628,	Mammoth White Surprise,	27,140	33,630	37,950	5,214	14,070
1687,	Pride of the North,	14,290	15,550	18,120	3,200	5,134
1688,	Smedley,	12,570	17,500	17,950	4,000	6,371
1624,	White Giant Normandy,	18,400	20,000	25,420	3,575	7,787
	Flints.					
1684,	Self-Husking,	4,695	9,797	14,050	....	....
1685,	Tuscarora,	11,400	19,120	....	....	....

The larger and coarser varieties, as Mammoth White Surprise, Chester County Mammoth, and White Giant Normandy, failed to fully ripen the corn. Blount's Prolific and Breck's Boston Market Ensilage also failed to mature, but these are recommended by seedsmen especially

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for ensilage. The first three varieties named might also be used for ensilage, although the stalks were very coarse and tough. The Self-Husking was the earliest variety, but gave the smallest yield. Of the other varieties the Golden Dent and Golden Beauty yielded better than the Smedley and Pride of the North.

YIELD OF DRY MATTER PER ACRE.

Water is so readily supplied to the animal that practically it may be disregarded in estimating the nutritive value of a fodder; consequently a more accurate mode of comparison is one based upon the yield of dry matter per acre. By dry matter is meant that portion of the plant remaining after the water has been dried out at a temperature a little above that of boiling water.

Corrected Yield per Acre—Dry Matter.

Station No.	NAME.	Fully tasseled.	Ears beginning to fill out.	Kernels beginning to glaze.	MATURE.	
					Ears.	Stover.
	Ensilage or Fodder.					
1751, .	Breck's Boston Market Ensilage,	1,561	1,641	4,264	2,440	3,920
1686, .	Blount's Prolific, ...	2,735	5,289	4,695	2,310	4,363
	Dents.					
1690, .	Chester County Mammoth, . .	3,392	4,337	5,690	3,073	4,308
1627, .	Golden Beauty (U. S. Dep't of Agriculture), ...	2,499	3,950	4,619	2,835	3,850
1629, .	Golden Beauty (P. Henderson & Co.), ...	2,845	3,443	4,636	3,077	4,427
1689, .	Golden Dent, ...	2,633	3,825	5,344	2,529	4,566
1628, .	Mammoth White Surprise, . . .	3,275	6,195	7,230	2,004	5,371
1687, .	Pride of the North, ...	1,581	2,213	3,761	2,195	. . . .
1688, .	Smedley, ...	1,297	2,213	3,761	2,917	. . . .
1624, .	White Giant Normandy, ...	2,162	2,764	4,037	2,176	4,638
	Flints.					
1684, .	Self-Husking, ...	408	1,212	2,048	. . . .	. . . .
1685, .	Tuscarora, ...	1,422	2,343	. . . .	. . . .	. . . .

It is found from the tables that while the percentage of water decreases as the plants advance in growth, the absolute amount of water increases. There are three exceptions to this, but as they are in connection with irregularities in yield, the results may not be outside the limits of error. There was also a rapid increase of dry matter per acre as the plants approached maturity, in many instances the amount of dry matter in the mature stover alone being nearly equal to that of the total crop at any other period of growth. The following figures show the gain in dry matter per acre between the different stages of growth:

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Gain of Dry Matter.

Station No.	Name.	Between—		
		First and second stage.	Second and third stage.	Third and fourth stage.
	Ensilage or Fodder.			
1751,	Breck's Boston Market Ensilage,	80	2,623	2,146
1686,	Blount's Prolific,	2,554	—605	2,932
	Dents.			
1690,	Chester County Mammoth,	945	1,353	1,791
1627,	Golden Beauty (U. S. Dep't of Agriculture),	1,451	669	2,066
1629,	Golden Beauty (P. Henderson & Co.),	597	1,193	2,868
1689,	Golden Dent,	1,192	1,519	1,751
1628,	Mammoth White Surprise,	2,920	1,035	145
1687,	Pride of the North,	632	1,548	3,568
1688,	Smedley,	916	1,548	5,527
1624,	White Giant Normandy,	602	1,273	2,777
	Average of all Dent varieties,	907	1,267	2,562

The average of the Dent varieties given in the table presents a good illustration of the rate of increase of dry matter per acre during the different stages of growth. By allowing the plants to mature there is considerably less weight of water to be handled, in proportion to the amount of actual food material, than there would be if they were cut and used when the kernels begin to glaze. At the same time the amount of valuable material (dry matter) is much greater.

FIELD-CURED MATERIAL.

The row cut for field curing was allowed to stand in the shock upwards of five weeks. The weather was quite unfavorable for proper uring. The corn was not in as good condition as it might have been had not the cold autumnal rains occurred at this time. The following table gives the results obtained:

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Yield per Acre—Fourth Period—Field-cured Material.

Station No.	NAME.	EARS.		STOVER.			
		Corn.	Cob.	Leaves and husks.	Upper half of stalks.	Lower half of stalks.	Total.
	Ensilage or Fodder.						
1751, .	Breck's Boston Market Ensilage, ...	2,984	986	4,440	920	4,240	9,600
1680, .	Blount's Prolific, ...	3,075	1,001	4,264	1,056	4,528	9,848
	Dents.						
1690, .	Chester County Mammoth, ...	4,007	1,091	4,356	1,040	5,274	10,670
1627, .	Golden Beauty (U. S. Dept. of Agriculture,)	4,005	1,267	4,680	909	4,409	10,000
1629, .	Golden Beauty (P. Henderson & Co.,)	4,545	1,295	4,702	1,409	5,909	12,020
1689, .	Golden Dent, ...	3,655	1,035	4,960	952	4,688	10,590
1628, .	Mammoth White Surprise, ...	3,620	1,594	5,404	1,762	6,904	14,070
1687, .	Pride of the North, . . .	2,650	550	. . . .	. . . .	. . . .	5,134
1688, .	Smedley, ...	3,290	710	. . . .	. . . .	. . . .	6,371
1624, .	White Giant Normandy, ...	2,746	829	4,127	680	2,980	7,787

In this table is given the yield of the separated parts in the fourth period. In this separation the weights of the more valuable portions of the stover, as leaves, husks and upper half of stalks, is given independently of the less valuable, and no doubt less nutritious portion, the lower half of stalks. It is impossible to give the separation of the Smedley and Pride of the North varieties. The total weight of the stover was obtained, but during separation circumstances prevented checking of results.

In the next table is shown the yield of dry matter per acre at the fourth stage:

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Yield of Dry Matter Per Acre—Fourth Period.

Station No.	Name.	Ears.		Stover.			
		Corn.	Cob.	Leaves and husks.	Upper half of stalks.	Lower half of stalks.	Total.
	Ensilage or Fodder.						
1751, .	Breck's Boston Market Ensilage, ...	1,860	580	2,426	376	1,116	3,920
1686, .	Blount's Prolific, ...	1,729	581	2,537	458	1,368	4,363
	Dents.						
1690, .	Chester County Mammoth, ...	2,417	656	2,502	596	1,210	4,308
1627, .	Golden Beauty (U. S. Dept. of Agriculture,)	1,996	839	2,399	339	1,112	3,850
1629, .	Golden Beauty (P. Henderson & Co.,)	2,384	693	2,408	525	1,494	4,427
1689, .	Golden Dent, ...	1,983	546	2,918	388	1,260	4,566
1628, .	Mammoth White Surprise, ...	1,374	630	2,946	600	1,825	5,371
1687, .	Pride of the North, . . .	1,827	368	. . . .	. . . .	. . . .	. . . .
1688, .	Smedley, ...	2,411	506	. . . .	. . . .	. . . .	. . . .
1624, .	White Giant Normandy, ...	1,671	505	2,596	308	1,734	4,638

In obtaining the yield of dry matter in the corn and cob, it was assumed that in the preliminary drying each dried out equally.

The proportion of the different parts as separated in this period is given in the following table, 100 representing the total yield of ears and stover.

Proportion of Parts—Dry Matter.

Station No.	Name.	Ears.		Stover.			Total.
		Corn	Cob.	Leaves and husks.	Upper half of stalks.	Lower half of stalks.	
	Ensilage or Fodder.						
1751, .	Breck's Boston Market Ensilage, ...	29.2	9.1	38.2	6.0	17.5	100
1686, .	Blount's Prolific, . . .	25.9	8.7	38.0	6.9	20.5	100
	Dents.						
1690, .	Chester County Mammoth, ...	32.7	8.9	33.9	8.1	16.4	100
1627, .	Golden Beauty (U. S. Department of Agriculture), ...	29.9	12.6	35.9	5.0	16.6	100
1629, .	Golden Beauty (P. Henderson & Co.), .	31.8	9.2	33.1	6.0	19.9	100
1689, .	Golden Dent, ...	28.0	7.7	41.1	5.5	17.7	100
1628, .	Mammoth White Surprise, ...	18.6	8.6	39.9	8.1	24.8	100
1687, .	Pride of the North,* .	31.8	6.6	Stover.	61.6	. . . . .	100
1688, .	Smedley,*	31.7	6.9	"	61.4	. . . . .	100
1624, .	White Giant of Normandy, ...	24.5	7.4	38.1	4.5	25.5	100

*These per cents. were obtained by using the yield of dry matter per acre with two exceptions. As the per cent. of dry matter was not determined in the Pride of the North and Smedley varieties, owing to an error in the separation of the stover, the yield of field-cured material was taken and the per cent. of corn, cob and total stover calculated.

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This season's work shows that for field crops such varieties as the Golden Beauty, Golden Dent, Smedley and Pride of the North are the best adapted for this and the northern sections of the State. The Chester County Mammoth, Mammoth White, Surprise and White Giant Normandy may be used successfully in the southern portion as a field crop. With us they did not mature, and could only be used for fodder. The question of merit would then largely turn on the palatability of the stalks and their digestibility. The facilities of the station would not allow the determination of the latter. The stalks of the varieties named were very hard and tough, and not to be preferred to those of Breck's Boston Market Ensilage and Blount's Prolific, the stalks of which were in better condition for fodder.

The following points may be given for guidance in the culture of the corn crop:

Good seed, purchased of reliable dealers or judiciously selected from previous season's crop.

Thorough plowing and pulverization of the ground.

Not too close and heavy planting, as for success there is needed exposure to sunlight and air.

Frequent cultivation and with as little manual labor as possible.

Not too much haste in harvesting, as it is shown from the results of this season's experiments that if the crop is allowed to mature there will be a considerable gain in valuable material for feeding purposes. At the same time the economy of harvesting will be greater, as there is relatively less water handle.

REMARKS ON THE FOREGOING EXPERIMENTS.

BY THE DIRECTOR.

It may be safely asserted that corn is one of the most important, if not the most important, crop in our State. According to the census of 1880, the production of corn and of wheat in Pennsylvania was as follows:

	Acres.	*Bushels.*
Corn,	1,373,270	45,821,531
Wheat,	1,445,384	19,462,405

The corn crop of the State, according to these figures, occupies almost as many acres, and produces nearly two and a half times as many bushels of grain as the wheat crop. Estimating corn at forty-five cents per bushel and wheat at ninety cents, the above corn crop would be worth over $20,000,000, and the wheat crop about $17,500,000. If we assume the proportion of corn to stover in this crop to have been the same as in the Dent corns grown at this Station the past year, the crop of stover corresponding to the above yield of corn would be fully 5,000,000 tons. This stover, as our experiments* have shown is a fodder of relatively high digestibility and value as com-

*Annual Report, 1887, pp. 144-157.

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pared with the straw of wheat. If we consider it worth three dollars per ton, this gives us $15,000,000 for the crop of the State. It is to be noted also that the census figures give us no information as to amount of corn grown solely for forage. It would apper then that $35,000,000 annually is a low estimate of the value of the corn crop of this State. Corn, too, has a double importance, being valuable both as a grain crop and as a forage crop. Owing to the large yields of excellent forage which it produces, it is very valuable in the latter respect to the cattle feeder, especially since the process of ensilage has been perfected, and it is an important factor in solving the problem of cheap production of meat and dairy products.

It consequently seemed desirable that the Station should make some study of the corn crop, especially of its value as a forage crop, both in the way of comparing varieties and of observing the yield and composition at different stages of maturity. The results reached in regard to the rate of growth of the crop in its later stages are worthy the careful attention of our farmers, especially since these results are entirely in accord with those of other investigators. Roberts,* for example, has investigated one variety of Dent corn at three periods of growth, bearing about the same relation to each other as the first three in our experiments. Calling the yield of dry matter per acre in the first period 100, the relative yields in the latter periods in Prof. Roberts' experiments and in ours were as follows:

Relative Yield of Dry Matter.

	First period.	Second period.	Third period.	Fourth period.
Roberts' experiments,	100	202	361	.....
Average of our experiments,	100	153	212	325

It may be added as an interesting fact that in our experiments the relative yield of stover in the fourth period was represented by 206, or an amount nearly equal to the total crop of the third period. Many other experiments might be adduced, illustrating the rapid increase of dry matter per acre in the corn crop in its later stages of growth. Since, now, a considerable part of the peculiar value of corn lies in its large yields per acre, it is evident this value can be fully realized only when a variety is selected which will mature or at least nearly mature in the locality; when the seeding is sufficiently thin to allow full access of light and air to the plants; and when the crop is permitted to grow until well advanced toward maturity. It appears from our results that there is a considerable increase of dry matter after the time when corn is usually cut for ensilage or for fodder. How far this increase can be utilized in the case of corn grown only

*Cornell University Experiment Station, First Report, p. 52.

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for forage is an important question, and one upon which further data are desirable. When corn is grown for ensilage, a certain proportion of moisture seems to be necessary in order that the material shall pack properly in the silo and keep without molding. With our present knowledge it seems doubtful whether corn grown for ensilage should be allowed to stand much longer than until the kernels are beginning to glaze. When the corn fodder is to be field cured this consideration, of course, has no force. As the corn approaches full maturity, however, it is probable that its digestibility decreases, but the few figures, as yet available, indicate that this decrease may not be very rapid. Experiments at this Station have given the following results as to the digestibility of corn planted in drills at the rate of three bushels per acre and cut while still young, and on the other hand, for stover from fully matured field corn:

Digestibility.

	Young corn fodder.	Stover.
Dry matter,	69	62
Ash,	61	44
Protein,	78	51
Crude fiber,	75	67
Nitrogen-free extract,	71	63
Fat,	40	52

While the stover is less digestible than the young fodder the difference is not very great. Moreover, the figures for the stover represent the digestibility of the stalks and leaves alone, and do not include the grain. Had this been included it is altogether probable that the coefficients would have been considerably larger. It seems altogether probable, in view of these results, that the decrease in digestibility between two of our periods was much less than the gain due to the rapid increase of total dry matter.

The general conclusion to be drawn from our experiments, then, as to the proper time of harvesting corn is that it should be allowed to stand as long as the climate of the locality and the purpose in view will permit, since it is continually increasing in value per acre.

WHEAT.

The number of varieties of wheat tested this season was six. They were sown in the fall of 1887 on ground receiving uniform treatment. The fertilizer used was 300 pounds per acre of a mixture composed of 1,800 pounds dissolved South Carolina rock and 200 pounds nitrate of soda. The seed of all the varieties originally came from the Department of Agricuture at Washington. That of Sibley's New Golden was received just prior to sowing; the others have been grown on Station farm for several years.

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939. Sibley's New Golden is a light bearded amber wheat, obtained by crossing the Mediterranean and Clawson. It is recommended as a first grade wheat with fine milling qualities.

The descriptions of the other five varieties given by the United States Department of Agriculture, and found in the report of this Station for 1887, are as follows:

948. Fulcaster:—"This hardy, prolific variety of wheat is believed to be a hybrid of two of our most celebrated, time-tested, hardy wheats, namely Fultz and Lancaster, as it has the straw, chaff and peculiar eight-row head of the Fultz, with the hardiness, long berry and beard of the Lancaster, really possessing all of the good qualities of both. This wheat has a stiff, white straw that will stand up well under almost any circumstances; a white, bearded chaff that clings to the grain, not shattering easily; heads long and massive, filled with large, plump, flinty, long berry grains. It ripens from three to six days earlier than most other varieties, and the yield is said to be fully equal to that of the Fultz. The originator also claims for it superior milling qualities. This wheat was originated in the Cumberland and Shenandoah Valley region, one of the foremost winter wheat regions in the United States."

946. Raub's Black Prolific:—"This bearded, short, stiff-strawed; prolific, hardy variety, grown near the District of Columbia, resembles Diehl Mediterranean very closely; it is believed, however, to be a new variety and may prove a valuable accession. It is, therefore, recommended for trial wherever the Fultz wheat has been successfully grown."

949. German Emperor:—"Imported from Germany by the grower, and thoroughly tested in north-western Ohio. It is a smooth wheat, having large compact heads, somewhat resembling the Clawson; it is highly recommended as being exceptionally hardy, and well adapted for culture on low lands where the soil is of a black and mucky character. It tillers or 'stools' out remarkably, and the straw is long and strong and stands up well. It ripens early, and is said to yield from one-fourth to one-third more than other varieties in the same locality."

947. McGhee's White:—"This is a hardy, early maturing variety, and worthy of general cultivation; the straw is of medium length and strong; the kernels are of medium size and the heads of good size, and generally perfect."

945. Extra Early Oakley:—"It is a beardless, hardy, prolific, stiff-strawed variety, and ripens from six to twelve days earlier than any any other variety in the same locality. The grain is of medium size and of amber color; a desirable accession."

All the varieties made a good fall growth and wintered well, The Extra Early Oakley ripened first. Sibley's New Golden ripened last, and not for several days after the others. All had strong straw, the

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average length being between four and four and three-fourth feet. The following table shows the yield per acre for 1887 and 1888:

Station number.	NAME OF VARIETY.	Number of years tried.	YIELD PER ACRE, '88.		Weight per bushel.	YIELD PER ACRE, '87.	
			Grain. Bus.	Straw. Lbs.		Grain. Bus.	Straw. Lbs.
939	Sibley's New Golden,.	1	20.00	1,525	58¾	. . . .	. . . .
948	Fulcaster, ...	2	29.87	3,325	63¼	14.40	2,259
940	Raub's Black Prolific,	2	27.58	2,850	65	19.30	2,906
949	German Emperor. . .	3	34.92	3,371	63	22.40	3,730
947	McGhee's White,. . .	3	28.20	2,432	65¾	16.50	2,369
945	Extra Early Oakley, .	3	22.12	2,282	64¾	18.40	2,900

It will be seen from the table that the German Emperor has given best results both this and last season. Raub's Black Prolific stood next in point of yield last season, but this year was exceeded by the Fulcaster. The small yield of the latter last season was mainly due to the ravages of the fly. These three may be placed foremost on the list on account of the yield and general hardiness. The Extra Early Oakley matured both seasons earlier than any of the other varieties, but its small yield is objectionable.

OATS.

Six varieties of oats were sown, four of them on one-twentieth acre plots, the other two on smaller areas. The ground for all was treated alike, South Carolina ground rock being applied at the rate of two hundred pounds per acre.

——. *White Victoria Oats:*—Seed from College stock; originally from the Department of Agriculture, and first tested in 1886. A variety of potato oats; plume of good white color, and bright lustre; quite heavy. As compared with the variety of potato oats commonly used here, it was six inches taller, had a stiffer stem, a fuller and more compact head, and was three or four days ahead in maturity.

1693. Japan Oats:—Seed received from H. Sibley & Co., Rochester, N. Y.; described by them as "A new and entirely distinct variety of White Barley oats being perfected by us for several years past upon our Burr-Oaks farm at Sibley, Ills. Straw is very stout and strong; berry, remarkably plump and full; average yield in excess of that of any standard variety ever raised by us; average weight forty-three and one-half pounds per bushel, stroke measure. A strong recommendation in favor of this variety is that it is absolutely rust proof."

1692. Wide Awake Oats:—Seed from H. Sibley & Co., Rochester, N. Y. This variety is recommended as having "Sufficiently firm and strong straw to prevent lodging of the luxuriant heads."

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1630. Henderson's Clydesdale Oats :—From Peter Henderson & Co., New York city. A variety of White oats, highly recommended for its extraordinary weight, earliness and productiveness.

1600. Welcome Oats :—Seed sent by the Department of Agriculture.

356. Harris Oats :—Seed originally from the Department of Agriculture; claimed to be a rust proof, loose husked variety originally from Alabama.

The varieties were all sown on April 23, 1888, and germinated well. May 2, all had acquired a good start, the only noticeable difference being in the thinness of stool of the Harris variety. The following table presents the data obtained during the season :

NAME OF VARIETY.	Per centage germination.	Date of heading.	Began to turn.	Ripe.	H'ht.	YIELD PER ACRE.		W't per bu.
						Grain bus.	Straw lbs.	
					Ft.			Lbs.
White Victoria,	.....	June 22,	July 16,	July 25,	3	37.76	1,640	37
Japan,	84	June 25,	July 12,*	.....	3½	41.54	2,180	39
Wide Awake,	93	June 25,	.....	Aug. 3,	3	†43.61	1,590	36
Henderson's Clydesdale,	94	June 26,	July 16,	July 25,	3	35.64	2,010	39
Welcome,	100	June 22,	July 16,	July 25,	3½	.....	.....	.....
Harris,	.....	June 18,	July 5,	July 14,	2½	.....	.....	28½

* Quite well colored. † Grain exceeded straw in weight.

The Japan and Wide Awake varieties matured and were cut at the same time, much earlier than the rest. The latter gave the best yield in grain, while the former yielded the most in straw, and the berries were plumper and better than those of any other variety. Henderson's Clydesdale, though the grain proved heavy, a stroke bushel at the time of threshing weighing thirty-nine pounds, was not a large yielder, and the straw was weak, being badly broken at time of cutting. The straw of the White Victoria oats was strong, yet the variety did not give a heavy yield. The Welcome oats, aside from weak straw, is worthy of further trial. This season's experience with the Harris variety only confirms that of the past two seasons. "This variety matures much earlier than our native varieties, but because of its dark color, inferior lustre and large proportion of husk, it is not to be preferred."* "This variety ripened nearly a week before the variety of potato oats commonly used here. At the time of harvesting, the height was three and one-third feet. It was quite limber and of small diameter. The heads were loose and of medium length; weight of 100 kernels was 2.43 grams; the weight of a struck bushel was twenty-eight and one-half pounds. As remarked in previous reports, it is, owing to its inferior weight, color and lustre, not of such character as to supplant the varieties now in use in Pennsylvania."†

* Pa. State College Agr. Exp. Station ; Report for 1886.
† Pa. State College Agr. Exp. Station ; Report for 1887, page 19.

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Barley.

Seed of two varieties was obtained from H. Sibley & Co., Rochester, N. Y.

1694. Hulless or Nepaul variety was sown broadcast, April 23, on a one-twentieth acre plot, which had received as fertilizer South Carolina ground rock at the rate of 200 pounds per acre. Seven days later the plants began to appear above ground, and in nine days from time of planting were well up. The germinative power as shown in germination tests, as reported in Bulletin No. 4, of this Station, was ninety-eight per cent. June 18 quite a number of heads were noticed. At time of cutting, July 13, the length of straw was two feet four inches. The straw was well colored and gave every appearance of ripeness, but it was found that the kernels were quite full of moisture. The heads were medium sized and well filled out with large kernels. The straw was weak and much of the plot had been broken by the wind and rain. The yield, as compared with that of the other variety grown, will be found in the table below.

1814. Manshury Barley.—An equal amount of seed was sown in the same manner and under similar conditions as with the above variety, but about a week later on account of delay in securing the seed. Though not sown until after the Nepaul, there was only a few days difference in the ripening of the two and this variety was in much better condition when cut. The straw was from four to eight inches longer and much stronger, and the yield was larger. It proved in this season's trial superior to the Nepaul. The only advantage gained by the latter was in the absence of hulls and beards. An interesting account of this variety is given in the first report of the Wisconsin Agricultural Experiment Station, it having been first introduced into the State from Germany, whither it was brought by a scientific traveler from the mountains of eastern Asia (Mandschurey), in 1859. On pages 18, 19 and 20 of above report, letters are published from H. Grunow, Esq., Mifflin, Iowa county, Wis., whose farm was the first for the dissemination of the seed in this country. The Wisconsin University Farm proved the second and the United States Department of Agriculture the third. The following extracts regarding the history of this variety are taken from the first report of the Agricultural Experiment Station of the University of Wisconsin.

"In answer to your request of January 3 about Mandschurey barley, I can state that while in Germany, in the spring of 1861, Ferdinand Duehlke, of Erfurt, at present director of the Agricultural School at Pottsdam, and gardener to the Emperor at Sans Souci, advised me to try a variety of barley which a scientific traveler had found in the mountainous parts of eastern Asia (Mandschurey), about 1859, and which had proved on trial to exceed the crop of any other variety, and to be number one for brewing purposes. In the first year of my

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experiment, with about two pounds of the seed, it excelled all varieties I had before seen in formation of roots, stems, leaves and ears, but the cattle from a neighbor's broke through the fence and destroyed the crop. The next year I found not a few of the plants that had been trampled, growing vigorously among grass and weeds as a proof of its hardiness, and concluded to send for seed again to compare it with the other kinds recommended for soils similar to ours, the two-rowed and six-rowed varieties from Peru, the Berbery, from Nepaul, Australia, Spain, Denmark, England, the Chevalier, etc., more than a dozen sorts, of which only the Mandschurey and Victoria proved worthy of cultivation. From one pound of seed of each I raised one and one-half bushels of Mandschurey, one bushel of Victoria (both six-rowed) and a peck or less of the rest. The Victoria was more white with a silvery shine, the Mandschurey darker, with olive or walnut green pigment. Two years later I sent a sample to your university, I advertised the merits in one or two papers, and farmers from neighboring towns and counties commenced to sow it exclusively. Maltsters declared it superior for malt, but merchants and brewers found it in their interest, at the expense of the farmers, to depreciate for stained color, which induced farmers to cut it before the natural color is developed, and causes loss in weight and price, and maybe degeneration. This is the history of Mandschurey barley so far as my experience goes."

The name of this variety has been spelled in many different ways. Prof. Daniells, of the Wisconsin University, spells it Manshury; the Agricultural Department has it Mensury, while Dr. Grunow writes it Mandschurey. A letter to Dr. Grunow upon this matter brought the following reply:

"In answer to yours, I can say that the barley was first introduced into Germany, and recommended under the name Mandschurei, or Mandschurey, from the country where it was found (the northwestern part of the Chinese Empire). In German geographies and maps, it is spelled Mandschurei (or ey), or called Amurland, or Tungusien. In German it would not be incorrect to use Mandschurey or ei, and omit the d. If I erroneously use Mandshury or Manshury, I thought it was the English expression for Manschoor."

"It would seem best to hold to the name used by Prof. Daniells and under which most of the barley has been distributed, viz: Manshury."

The following table shows the yield per acre of each variety:

STATION No.		Grain bu.	Straw lbs.	Weight of bushel.
1694	Nepaul, ...	20.00	1,210	52.00*
1814	Manshury, ...	30.63	1,730	51.25

*Scant bushel.

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The Nepaul had the heaviest grain, but did not produce as many bushels per acre as the Manshury.

Potatoes.

The following varieties were grown during the season:

Thorburn.—A seedling of the Beauty of Hebron.

Vanguard.—A very early variety.

College White.—The variety in general use in the College and Station farms.

Monroe County Prize.—Spoken of as a heavy yielder and good keeper.

Early Ohio.—Recommended on account of earliness rather than yield.

Early Beauty to Hebron.—A popular variety.

Dakota Red.—Said to thrive on both heavy and light soils, and very productive.

The seed of the College White variety was obtained from the stock on hand; that of the Thorburn from J. M. Thorburn & Co., New York city; of the Vanguard from Peter Henderson & Co., New York city; of the others from Hiram Sibley & Co., Rochester, New York. In each case one peck was used, and tubers were cut to single eyes and planted at the same time in rows three feet apart on plots receiving the same treatment.

The Vanguard and College White were the last to blossom. The Early Ohio and Early Beauty of Hebron ripened first and about the same time. The Vanguard ripened early but gave a poor yield. These were followed by the Thorburn, Dakota Red and Monroe County Prize. The College White was the last to ripen.

Station No.	Name.	Yield per Acre, Bush.			Proportion small to large.
		Small.	Large.	Total.	
. . . . .	Thorburn, ...	7.00	66.66	73.66	1: 9.5
. . . . .	Vanguard, ...	2.66	21.32	21.32	1: 7
. . . . .	College White, ...	14.00	139.83	153.83	1:10
1695	Monroe County Prize, . . .	8.00	125.33	133.33	1:15.7
1696	Early Ohio, ...	. . . .	. . . .	76.66	. . . .
1697	Early Beauty of Hebron, .	21.16	77.00	98.16	1: 3.2
1698	Dakota Red, ...	13.66	98.66	112.32	1: 7.2

In no case did the yield equal that of the variety usually grown on the College and Station farm—the College White—which gave smooth tubers of fair size, with eyes of medium depth. In point of yield, the Monroe County Prize stood next. This variety had a much smaller proportion of small or unmerchantable potatoes than any of the others. The potatoes were of good size with shallow eyes, but somewhat rough and irregular in outline. The objections to the Dakota Red variety, which stood third in yield, were the large propor-

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tion of small tubers and deep eyes. The merchantable potatoes were large, red and smooth, but with deep eyes. Of the two earliest varieties, the Beauty of Hebron made the largest yield, but the tubers were irregular, medium sized, with deep eyes, and this variety had the largest proportion of small tubers of any grown. By accident, some tubers of the other early variety—the Early Ohio—were removed before the time of sorting, and the proportion of small to large could not be accurately obtained. It was, however, less than with the other variety. The tubers were smooth and with shallow eyes, but much smaller than those of the Beauty of Hebron. The Thorburn this season proved a small yielder and with deep eyes. The proportion of small to merchantable tubers was also quite large. The variety which gave the smallest yield was the Vanguard. The tubers of this variety were, however, of medium size with shallow eyes.

From determinations of the percentage of water in the different varieties, made by the station's assistant chemists, Messrs. Holter and Sweetser, has been calculated the amount of dry matter (that is, matter other than water) produced per acre in the total crop and in the merchantable tubers.

Station number.	Name.	Yield per Acre.		Per cent. of dry matter.	Yield of Dry Matter per Acre.	
		Merchantable tubers.	Total crop.		Merchantable.	Total crop.
		Lbs.	*Lbs.*		*Lbs.*	*Lbs.*
.....	Thorburn, ...	4,000	4,420	20.89	835.60	923.34
.....	Vanguard, ...	1,120	1,280	19.46	217.95	249.09
.....	College White, ...	8,390	9,230	19.85	1,665.42	1,832.16
1695	Monroe County Prize, ...	7,520	8,000	18.82	1,415.26	1,505.60
1696	Early Ohio, ...	.....	4,600	19.28	.....	886.88
1697	Early Beauty of Hebron, ...	4,620	5,890	19.64	903.37	1,146.98
1698	Dakota Red, ...	5,920	6,740	17.61	1,042.51	1,186.91

Although the amount of dry matter produced per acre is a more accurate basis of comparison, it is found in this case that the relative yield of the varieties is but slightly changed when this is made the basis of comparison and the order of merit as regards productiveness is affected in but one instance. The Early Ohio ranks fifth in yield of fresh tubers and sixth in amount of dry matter produced per acre, exchanging places with the Thorburn.

In addition three seedlings were planted:

1631. Rural New Yorker.

1818. Mooer's Dakota Seedling.

1826. Ross' Favorite.

Each of the above was sent in such small quantity as not to permit the obtaining of any data as to yield. Those of the first two named were divided and plants started in the propagating pit. The last was planted in the field.

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The Rural New Yorker was received from J. M. Thorburn & Co., seedsmen, New York city, with the following description: "A new seedling medium early potato of unsurpassed beauty, remarkably fine quality, and wonderful yield." The tubers grown were of a very light color, of medium size, smooth, even, and with shallow eyes, a fine variety and worthy of more extended trial.

Mooer's Dakota Red Seedling originated in Dakota and bears the name of its originator, Mr. J. Mooer, Steele county, Dakota. Tubers received by the station were from J. A. Everitt & Co., seedsmen, Indianapolis, Ind. It yielded well, producing medium-sized, smooth tubers with shallow eyes, dark red skin, light colored pulp and very few small ones. A variety of some promise, and will be tried the coming season.

Ross' Favorite.—Sent by M. Murray, Centre, Ohio, it having originated with a friend of his by the name of Ross. Yielded smooth, red, shallow-eyed tubers. It blossomed early, but did not ripen as soon as the other two seedlings. Very large proportion of small tubers and some rot noticed.

FORAGE CROPS.

The following forage crops were grown during the season. From results obtained, three seem to merit further trial. Another season it is hoped to include them in systematic experiments on a larger scale, in which a comparison of them will be made with the soiling crops now successfully grown here, viz: corn, clover and rye.

1815. Prickly Comfrey.—A plant that has not as a general thing been grown successfully for forage purposes in this country. Dr. Henry Foster, of Clifton Springs, N. Y., and some Wisconsin dairymen, have found it both economical and desirable. Dr. Foster's experience is cited in the sixth annual report of the New York State Agricultural Experiment Station, where are published letters from him to the chemist, Mr. Ladd. In one he informed Mr. Ladd that "he secured five crops each season, and that he expected the produce from these five crops would furnish one-half of the fodder, other than the grain, for his herd of fifty cows from May until October. He was then feeding two rations per day of corn ensilage and two of comfrey, with mixed grain."

"We have been using comfrey five years and we think more of its value this year than in the previous years. We are now cutting the fifth crop grown this season. My foreman says it will average ten tons to the acre for each crop, making fifty tons to the acre for the season. Of course, to get such an enormous yield, it must be thoroughly cultivated between each cutting and top dressing. We use for dressing nothing but stable manure, put on immediately after cutting, before cultivating. We have no forage plant that compares with it in producing quantity and quality of milk."

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Ten roots were obtained last spring from Hiram Sibley & Co., Rochester, N. Y. They were set out in rows three feet apart, and from one to one and one-half feet in the row. The growth was cut three times during the season, and the computed yield per acre was eight and one-fourth tons of green fodder. It should be taken into consideration in this trial that the plants were young and not fully established, and a heavier yield may reasonably be expected another season. The plants grew well, notwithstanding rough handling at time of cutting, and if they prove hardy the crop may find a place on our list of forage crops in the State.

1622 and 1626: Kaffir Corn.—A variety of sorghum cultivated for both forage and grain. Seed was obtained from Peter Henderson & Co., New York city, and from the United States Department of Agriculture, and showed germinative power of ninty-one to ninety-two per cent. It was sown in drills May 16, 1888, and appeared above ground June 7. During the season a growth of five and one-half feet was made and the yield was at the rate of five and one-half tons of green fodder per acre. Though the stalks had become very hard it was relished by the cattle. No difference was noticed in the growth from the two lots of seed.

Cow Pea:—Some seed of the Black Eye variety was secured of D. Landreth & Sons, Philadelphia, and sown in drills three and one-half feet apart, the 19th of June. Six days later the plants appeared above ground and on the 11th of July had commenced to branch. September 29 and October 1 and 2 the growth was cut for fodder. Some few pods had formed, but none had filled out. It was sown this season on a vacant plot, and simply to make observations on its growth. Although the yield was light (seven and one-fourth tons of green fodder per acre), it seems probable that when grown on land especially prepared for soiling purposes a profitable yield may be obtained.

1606. Teosinte (Euchloena luxuriens):—Seed from the United States Department of Agriculture. The plant is described by it as follows: "A luxurant forage plant which has not yet become sufficient acclimated to produce seed north of Florida, or the thirty-first degree of latitude. An annual crop of green or dry fodder or ensilage can be grown as far north as the fifty-first parallel. Stock of all kinds are exceedingly found of it, either green or cured." In germination tests only sixty-two per cent. of this seed sprouted, and upon being sown upon the plot, only two or three hills came up, and these amounted to nothing. The failure is attributed to poor seed.

1700. White Mustard:—Seed was obtained from Hiram Sibley & Co., Rochester, N. Y., and sowed as a forage crop. In the germination test of the Station, reported in bulletin No. 4, ninety-five per cent. of this seed sprouted. It was sown May 3, in rows one foot apart, on a plot

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receiving South Carolina ground rock at the rate of 300 pounds per acre. May 9, the plants showed above the ground and on June 14 were cut. At time of cutting it was in full bloom and some seeds had commenced to form. None of the plants sent up shoots, after the cutting. This, combined with smallness of yield, scarce a ton per acre, would not recommend it for forage purposes.

1623. Brazilian or Flour Corn:—Seed from the United State Department of Agriculture, planted May 16, 1888, in hills three by three and one-half feet. Germinative power eighty-four per cent. Was very prolific of ears and made a growth of seven feet during the season, but did not mature before frost came, October 18. Only in a few cases were the kernels commencing to glaze.

Samples of the White Mustard, Prickley Comfrey and Kaffir corn were taken at the time the crops were cut, and were subsequently subjected to chemical analysis. The following table shows the composition of the plants in the green state. No analysis was made of the Cow pea, and the figures in the table show the average composition of this crop as found by other analyses:

Composition of Green Forage Plants.

Station number.	NAME.	Moisture.	Fat.	Crude fiber.	Nitrogen-free extract.	Protien.	Ash.	Sand.
1971	White Mustard, ...	84.19	.51	2.04	4.84	4.34	2.25	1.83
2011	Prickley Comfrey, 1st cutting, ...	89.18	.26	1.13	3.68	2.43	1.52	1.80
2027	Prickley Comfrey, 2d cutting, ...	87.49	.25	1.19	3.72	2.59	1.57	3.19
2308	Prickley Comfrey, 3d cutting, ...	86.65	.27	1.25	5.91	1.92	1.76	2.24
2309	Kaffir Corn, ...	76.13	.78	6.16	11.96	3.22	1.75	. . . .
	Cow Pea*	84.07	.60	3.48	6.90	3.12	1.83	. . . .

*Average composition. Report Connecticut Agricultural Experiment Station, 1887, page 184

From the figures of the above table and the total yield, we may compute the number of pounds of each constituent of the crop produced per acre, as has been done in the table below:

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Yield of Crude Nutrients—Pound per Acre.

	White Mustard.	Prickley Comfrey.*	Kaffir corn.	Cow Pea.
Water,	1,684	14.483	8,374	12,190
Fat,	10	43	86	87
Crude fiber,	41	196	678	504
Nitrogen-free extract,	97	733	1,316	1,000
Protien,	86	381	354	453
Ash,	45	266	193	266
Sand,	37	398	.....	.....
Total yield,	2,000	16,500	11,000	14,500

*Computed from avearge composition of the three samples.

It is not, however, the total yield per acre of a crop but the amount of digestible material which it contains which determines its value as a cattle food. Neither the quantity of material produced on these small plots nor the means of the Station permitted a determination of the digestibility of these crops. We may, however, make an approximate calculation of the product of digestible material per acre by using the results of digestion experiments made elsewhere upon similar material. The following are the coefficients of digestibility used in this calculation. Those for the Prickley Comfrey are from experiments made in Germany. Those for the Kaffir corn are coefficients obtained for ordinary fodder corn in digestion experiments at this Station. Those for the Cow Pea are the coefficients given by Wolff for green clover, no digestion experiments having yet been made upon the Cow Pea. In the case of White Mustard, likewise, no digestion experiments have been reported either upon this particular crop or any other very similar to it, so that in view of the evident unimportance of the crop under our circumstances, it seems safest not to attempt any calculations of the yield of digestible matter in this case.

Green Forage Plants—Coefficients of digestibility (per cent.).

	White Mustard.	Prickly Comfrey.*	Kaffir Corn.†	Cow Pea. ‡
Fat,	None.	71	40	62
Crude fiber,	None.	18	75	49
Nitrogen-free extract,	None.	85	71	69
Protein,	None.	58	78	62

* Mentzel und v. Lengerke's Landw. Kalender, 1888.

† Obtained by this station with fodder corn. See following pages.

‡ Wolff's coefficients of digestibility of "Green Clover and Clover Hay."

The next table shows, upon the basis of the above figures, the yield per acre of total digestible organic matter and of its several constituents per acre. Any further comment upon these results or comparison

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of these crops with others is withheld until we can give the results of further experiments undertaken under more favorable conditions.

Yield of Digestible Material—Pounds per acre.

	Prickly Comfrey.	Kaffir Corn.	Cow Pea.
Fat,	30.5	34.2	53.9
Crude fiber,	35.3	33.2	247.0
Nitrogen-free extract,	623.1	907.8	690.0
Protein,	221.0	119.4	280.9
Total digestible organic matter,	909.9	1,094.6	1,271.8

FEEDING STANDARDS AND COMPOSITION OF FEEDING STUFFS.

BY H. P. ARMSBY.

As explanatory of some of the terms used in subsequent papers upon feeding experiments, and for the general information of the farmers of the State, it has been thought well to insert in the present report a brief explanation of some of the fundamental principles of fodder analysis and cattle feeding.

The body of an animal consists mainly of four classes of substances, viz:

1. Water; which makes up from 40 to 60 per cent. of the weight of the live animal, and is just as essential a part of its tissues as any other ingredient.

2. Ash, or mineral matters; amounting to from 2 to 5 per cent. of the weight and constituting a considerable proportion of the bones and a smaller proportion of the soft tissues.

3. Fat; varying greatly in amount according to the condition of the animal, but seldom falling below 6 per cent. or rising above 30 per cent.

4. Protein; a name given to an important group of substances, of which washed lean meat or the white of egg may be taken as the type. They all contain about 16 per cent. of the element nitrogen, which is entirely lacking in the three other groups, and are remarkably alike in their general properties. The organic part of the bones, the ligaments and muscles which bind together and move the bones, the skin, the internal organs, the brain and nerves, in short, all the working machinery of the body, are composed very largely of portein. Consequently this group of substances is of great importance, and a due supply of it in the food, particularly to growing animals, is indispensable.

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The following table shows more in detail the average chemical composition of different animals, in different stages of fatness.

Average Composition of Live Animal.

	Ox.			Calf.	Sheep.					Swine.	
	Well fed.	Half fat.	Fat.	Fat.	Lean.	Well fed.	Half fat.	Fat.	Very fat.	Well fed.	Fat.
Water, .	66.2	59.0	49.5	64.6	67.5	63.2	58.9	50.9	43.3	57.9	43.9
Ash, . .	5.9	5.2	4.4	4.8	4.0	3.9	3.8	3.3	3.1	2.9	1.9
Fat, . .	8.7	17.5	30.5	14.1	10.2	15.5	21.3	31.9	41.4	24.2	42.3
Protein,	19.2	18.3	15.6	16.5	18.3	17.4	16.0	13.9	12.2	15.0	11.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In the food of the animal, we find the same four groups of substances which we do in the body of the animal, viz: water, ash, fat and protein, and in addition large quantities of a class of bodies called carbhydrates. Starch, sugar and woody fibre are the commonest representatives of this class. They contain no nitrogen, are all digestible to a greater or less extent, and, with the exception of woody fiber, very readily and completely so.

What purpose, now, do these ingredients of the food serve in the animal economy? To simplify matters, we may leave out of account the water and ash. The chief supply of water to the animal is in its drink, and we do not employ fodder for the sake of its water. The ash is essential to the well-being of the animal, but any reasonably sufficient ration will abundantly supply the small amount required by the body. There remain to be considered the protein, fat and carbhydrates. The protein of its food is used by the animal to supply the wear and tear of its working machinery, which, as above stated, is largely composed of this substance; to supply the material for growth in the case of young animals; for the production of wool in sheep, and for the casein of the milk in milking animals. For these purposes it is absolutely indispensable. No other substance can be worked over into protein by the body. The amount of protein which the ration must contain will vary with the kind of animal and the purpose for which it is fed, but a certain minimum amount is always necessary.

The fat and carbhydrates of the food serve two purposes in the animal economy. First, they are burned as fuel to keep the animal warm, and to supply the force necessary for its internal and external motions. For this purpose a pound of fat is about 2.2 times as valuable as a pound of carbhydrates. Second, the carbhydrates and fat serve as sources of fat. Their relative value in this respect has not been determined, but it is not improbable that it is about the same as

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for the production of heat. Finally, when more protien is fed than is needed for growth and repair, this also is utilized as fuel or as fat forming material. For fuel it is worth about 1.1 times as much as the carbhydrates, as a fat producer less than six-tenths as much. An unnecessary use of protien for fuel or fattening, however, is not usually economical, because it is commonly the most expensive ingredient of the food to produce or buy.

In view of these considerations, it is plain that, in feeding for different purposes, different amounts and proportions of digestible protein, carbhyrates and fat will be required in the ration. The attempt has been made to formulate, in what are called feeding standards, the requirements of various kinds of animals in this respect, and Wolff's standards in particular have been widely circulated in this country, and have been the subject of no little discussion. They are as follows:

FEEDING STANDARDS.

A.—Per Day and per 1,000 lbs. Live Weight.

	Total organic substance.	Nutritive (digestible) substances.			Total nutritive substance.	Nutritive ratio.
		Protein.	Carbhydrates.	Fat.		
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1. Oxen at rest in stall	17.5	0.7	8.0	0.15	8.85	1 : 12.
2. Wool sheep, coarser breeds	20.0	1.2	10.3	0.20	11.70	1 : 9.
Wool sheep, finer breeds	22.5	1.5	11.4	0.25	13.15	1 : 8.
3. Oxen moderately worked	24.0	1.6	11.3	0.30	13.20	1 : 7.5
Oxen heavily worked	26.0	2.4	13.2	0.50	16.10	1 : 6.
4. Horses moderately worked	22.5	1.8	11.2	0.60	13.60	1 : 7.0
Horses heavily worked	25.5	2.8	13.4	0.80	17.00	1 : 5.5
5. Milk cows	24.0	2.5	12.5	0.40	15.40	1 : 5.4
6. Fattening oxen, 1st period	27.0	2.5	15.0	0.50	18.00	1 : 6.5
Fattening oxen, 2d period	26.0	3.0	14.8	0.70	18.50	1 : 5.5
Fattening oxen, 3d period	25.0	2.7	14.8	0.60	18.10	1 : 6.0
7. Fattening sheep, 1st period	26.0	3.0	15.2	0.50	18.70	1 : 5.5
Fattening sheep, 2d period	25.0	3.5	14.4	0.60	18.50	1 : 4.5
8. Fattening swine, 1st period	36.0	5.0	27.5		32.50	1 : 5.5
Fattening swine, 2d period	31.0	4.0	24.0		28.00	1 : 6.0
Fattening swine, 3d period	23.5	2.7	17.5		20.20	1 : 6.5
9. Growing cattle:						
Age, Months. *Average live weight, per head.*						
2—3 150 lbs	22.0	4.0	13.8	2.0	19.8	1 : 4.7
3—6 300 lbs	23.4	3.2	13.5	1.0	17.7	1 : 5.0
6—12 500 lbs	24.0	2.5	13.5	0.6	16.6	1 : 6.0
12—18 700 lbs	24.0	2.0	13.0	0.4	15.4	1 : 7.0
18—24 850 lbs	24.0	1.6	12.0	0.3	13.9	1 : 8.0
10. Growing sheep:						
5—6 56 lbs	28.0	3.2	15.6	0.8	19.6	1 : 5.5
6—8 67 lbs	25.0	2.7	13.3	0.6	16.6	1 : 5.5
8—11 75 lbs	23.0	2.1	11.4	0.5	14.0	1 : 6.0
11—15 82 lbs	22.5	1.7	10.9	0.4	13.0	1 : 7.0
15—20 85 lbs	22.0	1.4	10.4	0.3	12.1	1 : 8.0
11. Growing fat pigs:						
2—3 50 lbs	42.0	7.5	30.0		37.5	1 : 4.0
3—5 100 lbs	34.0	5.0	25.0		30.0	1 : 5.0
5—6 125 lbs	31.5	4.3	23.7		28.0	1 : 5.5
6—8 170 lbs	27.0	3.4	20.4		23.8	1 : 6.0
8—12 250 lbs	21.0	2.5	16.2		18.7	1 : 6.5

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B.—Per day and per Head.

		Total organic substance.	Nutritive (digestible) substances.			Total nutritive substance.	Nutritive ratio.
			Protein.	Carbhydrates.	Fat.		
Growing cattle:							
Age. Months.	*Average live weight, per head.*	lbs.	lbs.	lbs.	lbs.	lbs.	
2—3	150 lbs.	3.3	0.6	2.1	0.30	3.00	1:4.7
3—6	300 lbs.	7.0	1.0	4.1	0.30	5.40	1:5.0
6—12	500 lbs.	12.0	1.3	6.8	0.30	8.40	1:6.0
12—18	700 lbs.	16.8	1.4	9.1	0.28	10.78	1:7.0
18—24	850 lbs.	20.4	1.4	10.3	0.26	11.96	1:8.0
Growing sheep:							
5—6	56 lbs.	1.6	0.18	0.87	0.045	1.095	1:5.5
6—8	67 lbs.	1.7	0.17	0.85	0.040	1.060	1:5.5
8—11	75 lbs.	1.7	0.16	0.85	0.037	1.047	1:6.0
11—15	82 lbs.	1.8	0.14	0.89	0.032	1.062	1:7.0
15—20	85 lbs.	1.9	0.12	0.88	0.025	1.025	1:8.0
Growing fat swine:							
2—3	50 lbs.	2.1	0.38	1.50		1.88	1:4.0
3—5	100 lbs.	3.4	0.50	2.50		3.00	1:5.0
5—6	125 lbs.	3.9	0.54	2.96		3.50	1:5.5
6—8	170 lbs.	4.6	0.58	3.47		4.05	1:6.0
8—12	250 lbs.	5.2	0.62	4.05		4.67	1:6.5

"Total organic matter" signifies the combustible portion of the ration, free from water and ash. The difference between "total organic matter" and "total nutritive substance" shows the amount of indigestible matter in the ration and thus indicates something as to its proper bulk. The "nutritive ratio" is the ratio of digestible protein to the sum of the digestible carbhyrates and fat. For animals weighing more or less than 1,000 pounds, the quantities are to be increased or diminished in proportion to the weight.

In using one of these standards we endeavor to fix upon a mixture of feeding stuffs which shall contain in a reasonable bulk the amounts of digestible matters called for by the standard. To do this we need to know how much digestible matter the fodders which we are to use contain. The following table shows the average composition and content of digestible matters of some common fodders. The composition of the fodders is taken chiefly from Dr. E. H. Jenkins' compilation of American analyses in the report of the Connecticut Agricultural Experiment Station; the digestibility is computed from the results of German experiments.

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Average Compositian of Feeding Stuffs.

	Number of analyses.	Percentage Composition.						Per Ct. of Digestible Matter.		
		Water.	Ash.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.	Protein.	Carbhydrates.	Fat.
Pasture grass,	.....	80.0	2.0	3.5	4.0	9.7	0.8	2.5	9.9	0.4
Corn ensilage,	53	80.5	1.3	1.5	5.8	10.2	0.7	1.1	11.0	0.5
Clover ensilage,	3	76.3	2.5	3.3	6.7	10.2	1.0	2.2	11.0	0.6
Clover hay,	25	12.6	6.1	12.6	26.6	39.6	2.5	6.9	37.7	1.3
Timothy hay,	40	11.1	4.1	6.0	30.9	45.8	2.1	3.1	43.3	0.9
Hay from mixed meadow grasses,	9	15.5	4.7	6.2	31.1	40.4	2.1	3.2	40.2	0.9
Corn fodder—field cured,	6	32.1	4.3	4.3	22.1	36.0	1.2	2.5	35.1	0.6
Oat straw,	4	9.6	5.2	3.5	43.4	36.1	2.2	1.4	42.6	0.7
Rye straw,	2	11.1	5.4	4.5	38.8	38.4	1.8	1.0	37.5	0.6
Wheat straw,	1	6.5	7.0	5.0	38.1	42.0	1.5	0.9	37.7	0.5
Mangolds,	5	91.8	1.0	1.5	0.9	4.7	0.2	1.1	4.5	.....
Rutabagas,	1	87.1	1.4	1.2	1.2	9.1	0.1	0.7	8.1	.....
Turnips,	1	88.9	0.7	1.3	0.9	8.1	0.1	0.8	7.2	.....
Potatoes,	6	78.5	0.9	2.1	0.5	17.9	0.1	1.4	16.6	.....
Peas,	.....	13.2	2.4	22.4	6.4	52.6	3.0	19.7	55.0	1.5
Barley,	9	10.9	2.4	12.4	2.6	69.9	1.9	9.7	62.0	1.7
Oats,	25	10.9	3.0	11.4	9.9	60.1	4.8	9.8	48.0	3.9
Rye,	6	11.6	1.9	10.6	1.6	72.6	1.7	8.5	58.4	1.5
Wheat,	310	10.5	1.9	11.8	1.8	71.9	2.1	9.5	60.9	1.9
Corn (Maize),	190	10.5	1.6	10.6	2.1	69.8	5.5	8.4	64.8	4.7
Sorghum seed,	9	12.5	1.8	8.9	1.9	71.3	3.7	7.6	68.5	2.8
Malt sprouts,	3	10.3	5.7	23.0	10.7	48.6	1.8	18.8	48.1	0.9
Brewers' grains,	15	75.0	1.0	5.6	3.9	12.9	1.7	4.1	9.6	1.4
Cotton seed meal,	24	8.3	7.3	42.1	5.7	23.4	13.2	35.8	22.3	11.7
Oil meal—old process,	9	9.2	5.9	31.5	9.3	36.3	7.8	27.1	34.3	7.0
Oil meal—new process,	12	10.7	5.6	32.9	9.5	38.3	3.1	28.3	34.8	2.8
Rye bran,	5	11.5	8.7	15.4	8.6	63.4	2.5	10.2	47.7	1.5
Wheat bran from roller mills,	7	12.0	5.6	16.1	8.4	53.7	4.2	12.6	44.1	2.9
Wheat bran—old process,	9	12.0	4.9	13.0	8.1	58.2	3.8	10.2	47.5	2.6
Wheat shorts,	8	12.7	4.3	13.8	7.5	57.6	4.1	10.8	46.8	2.8
Gluten meal,	8	9.1	0.8	29.9	1.5	52.6	6.1	23.6	43.8	5.2

As an illustration of the manner in which these tables of feeding standards and of the composition of feeding stuffs are intended to be used, we may compute a ration for a milch cow weighing 1,000 pounds.

As the foundation for a ration, let us take 20 pounds of corn ensilage and 10 pounds of clover hay. The first step is to estimate how much digestible matter these will furnish. According to our table, average ensilage contains 80.5 per cent. of water and 1.3 per cent. of ash, and consequently 100—80.5—1.3=18.2 per cent. of dry organic matter, together with 1.1 per cent. of digestible protein, 11.0 per cent. of digestible carbhydrates, and 0.5 per cent. of digestible fat. Twenty pounds of it would therefore contain 3.61 pounds of total organic matter; 0.22 pounds of digestible protein; 2.22 pounds of digestible carbhydrates; 0.10 pounds of digestible fat.

In the same way we estimate the amount of organic matter and of digestible substances contained in ten pounds of clover hay, and we find that the coarse fodder of the proposed ration furnishes the following amounts of nutritive matters:

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	Organic matter.	Digestible.		
		Protein.	Carbhydrates.	Fat.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
20 pounds of ensilage,	3.61	0.22	2.22	0.10
10 pounds of clover hay,	8.00	0.63	3.80	0.10
Total,	11.61	0.85	6.02	0.20

This naturally falls considerably short of the standard, and the deficiency must be made up with grain or meal of some sort. The market price will usually be an important factor in deciding what kinds shall be used. We will suppose, however, that a mixture of corn meal and bran has been fixed upon; what amounts of each shall we take to complete the ration? This we must find by trial. We start with, say, five pounds of each, and calculate from the table how much digestible matter they will supply. Having done this, our table stands as follows:

	Organic matter.	Digestible.		
		Protein.	Carbhydrates.	Fat.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
20 pounds of ensilage,	3.61	0.22	2.22	0.10
10 pounds of clover hay,	8.00	0.63	3.80	0.10
5 pounds of corn meal,	4.40	0.46	3.35	0.21
5 pounds of bran,	4.09	0.61	2.21	0.16
Total.	20.10	1.92	11.58	0.57

The ration still falls short of the standard. Before increasing the quantity of bran or meal, however, let us see exactly what is lacking. We need still 0.58 pounds of protein and 0.92 pounds of carbhydrates, while the fat is already in excess. It is plain that neither corn meal nor bran will answer to complete the ration, because if enough of either be added to increase the protein to the required amount the amount of carbhydrates will be raised far too high. What we want is some feeding stuff containing plenty of protein and but little carbhydrates and fat. One such fodder is new process oil meal. We add two pounds of that to the ration, and it then stands thus:

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	Organic matter.	Digestible.		
		Protein.	Carbhydrates.	Fat.
Ration as above,	20.10	1.92	11.58	0.57
Two pounds oil meal,	1.88	0.54	0.56	0.07
Total,	21.98	2.46	12.14	0.64
Standard,	24.00	2.50	12.50	0.40

By the addition of the oil meal the ration is made to correspond as closely as is necessary with the standard. While it contains somewhat less carbhydrates than the standard, it contains enough fat to make up the difference. It is quite possible that the actual ration when weighed out would not approach as near to the standard as it does on paper. It must not be forgotten that we are working with averages, both as to composition and digestibility. Any particular fodder is liable to differ more or less from these averages, and therefore all calculations of rations can be approximate only.

Many other combinations of feeding-stuffs might be readily computed which would contain very nearly the amounts of digestible matters called for by the standard. In general, any mixture of wholesome feeding-stuffs which contains the amounts of digestible matter called for by any particular standard, and has a suitable bulk, is a good ration for that particular purpose.

There has been a somewhat general tendency on the part of American experimenters and writers of late years, to question the accuracy of these German standards, or at least their applicability to our conditions. One cause of this tendency has doubtless been a too literal interpretation of the feeding standards. It has frequently been assumed, tacitly, if not avowedly, that a feeding standard was the exact expression of a scientific fact, instead of being, as it really is, an average of the results of more or less numerous and exact feeding trials. If, for example, a ration differing more or less from the standard for some purpose, say fattening, has produced as good or better results than one compounded in accordance with the standard, there has been a feeling that the whole system of calculating rations is thereby discredited, whereas it may simply show that further experiment is needed in certain directions.

But making all allowance for this mistaken feeling, it is undoubtedly the fact that some of the feeding standards given above, notably those for maintenance and for fattening, have failed to prove of much service to those who have tried them in this country, while others, notably that for milk, have given more general satisfaction. Even the latter standard, however, apparently does not always indicate the most *economical* feeding for our present conditions.

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It is worthy of note that the standards for maintenance and for fattening are precisely those which embody the least experience, while that for milk represent the results of a larger number of experiments. This fact certainly suggests the possibility that further experiments may result in establishing standards for other purposes as satisfactory as that for milk or even more so. In any case, however, these standards are, and are intended to be, simply *aids* to rational feeding, and not infallible formulæ to be blindly followed.

THE SOILING SYSTEM FOR MILCH COWS.

BY H. P. ARMSBY, WILLIAM FREAR, H. J. PATTERSON, GEORGE L. HOLTER AND WM. H. CALDWELL.

As the value of land increases and the cost of interior fences becomes felt to be as a growing burden, there is a natural incentive toward producing milk and butter from as small an area as possible, and as a result the question of the economy of the soiling system becomes of growing interest. By this system a much larger amount of fodder can be grown per acre than is produced by average pastures, and the adoption of the system will turn largely on the question whether the gain in this direction under any given circumstances is sufficient to more than cover the extra labor involved in cutting the crop and carrying it to the animals. Other considerations are, of course, involved, as for example, the fact that in pasturing stock there is considerable loss through the trampling of the grass by the animals and in other ways. Further, the fact of the irregularity in the yield of pasture at different seasons, as illustrated in one of the experiments described below, is an important element in the case.

Where animals are fed exclusively on green fodder, the expense of cutting and carrying the fodder to them is very considerable. On the other hand, when dairying is the main business, pastures are rather unsatisfactory as a sole reliance throughout the summer season. Many advanced dairymen have sought to combine the advantages of pasturage and soiling by a system of partial soiling, depending wholly or mainly upon the pastures early in the season, and supplementing them with clover or corn later when the growth of the grass falls off. The system of feeding which has been practiced upon this farm for several years is another form of partial soiling. We have no pastures, the cattle being fed entirely in the barn or yard. During the summer season they receive about half their fodder in the form of hay and grain and the remainder in the form of the various soiling crops. They are fed in the barn or yard night and morning and during the day are

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allowed to run in a small piece of woodland where they have the benefit of the shade and coolness, but where they get no appreciable amount of fodder. Quite extensive investigations of the yield and composition of soiling crops have already been carried on here by Dr. Frear previous to the establishment of the Station. The investigations reported below, while supplying additional data on this point, have a more extended scope.

They include:

1. An investigation of the yield and composition of pasture grass.
2. A determination of the digestibility and nutritive value of young grass, including also a comparison of the digestibility and nutritive effect of green grass with those of the same grass dried.
3. Digestibility of soiling crops.
4. Observations on the yield per acre of soiling crops, the composition of rations actually eaten by the cows, the yield and composition of milk, and the area of soiling crops required per cow and per 100 pounds of milk produced.

Exact knowledge on these fundamental points is necessary before a satisfactory estimate can be made of the relative cost and profit o pasturing and soiling. These experiments are an attempt to add to our present meager knowledge on this point. They are, however, only a beginning in this direction. All these factors necessarily vary with locality, and with the season, and a single year's work cannot settle any of them definitely. Moreover, in these experiments, we simply took the system which has been in use here for a number of years as the basis of investigation. The rations fed are not proposed as models. In fact, it is not improbable that they could be improved. The cows used, moreover, were far from being the best, and this results in making the cost of production considerably higher than it should be, although this does not necessarily affect the value of the comparisons drawn between soiling and pasturage. In short, this present report is a report of progress. It was necessary to make a beginning if we were ever to have definite knowledge on this subject. It is our hope to be able to continue and extend these investigations in future years until sufficient data are accumulated for some definite conclusions.

Yield and Composition of Pasture Grass.

H. P. ARMSBY, H. J. PATTERSON AND GEORGE L. HOLTER.

As noted above, the object of this experiment was to obtain data as to the chemical composition of pasture grass and the amount produced per acre, as a basis for comparison with soiling crops. The general plan of the experiment originated with the Director; the execution and a considerable part of the calculations were in the hands of Messrs. Patterson and Holter, Mr. Patterson having charge of the

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exteriment until his resignation, in June, and Mr. Holter after that date. Having no pastures, it was necessary to find some spot which should represent as nearly as might be an average pasture. For this purpose a portion of the college campus was selected where the grass did not appear particularly luxuriant or, on the other hand, especially thin. The grass was an old blue-grass sod, with a quite liberal admixture of white clover, having a gradual slope to the south-east. A plot one rod wide and seven rods long was staked out and subdivided into seven portions each one rod square. The grass upon this plot was cut with a lawn mower having attached to it a grass box which caught all or practically all the grass as it came from the knives. The sub-plots were cut in this way, one at a time, in regular rotation throughout the season, the grass after cutting being taken to the laboratory as promptly as possible, accurately weighed, and sampled for analysis. The object of sub-dividing the plot into seven sub-plots was to follow the daily rate of growth as closely as possible, and the intention was to cut one sub-plot each day. It was soon found, however, that daily cutting was too frequent, and during nearly all of the experiment the time of cutting was governed by the rate of growth of the grass. Each successive set of seven samples taken as above, and representing consequently the yield of the whole plot, was united and subjected to chemical analysis. In the tables which follow in this report only averages for the whole plot are given. While it would be interesting to trace out the daily yield as shown by the individual cutting, the general result would not be different from that given by the averages.

COMPOSITION OF GRASS.

As was to be expected, the grass varied more or less in composition at different times. A study of these variations would be interesting, but it is sufficient for our purpose to give the average composition of the grass which was as follows:

Composition of Pasture Grass.

	Fresh.	Water Free.	Wolff's average water free.
Water,	73.87		
Ash,	2.46	9.23	10.0
Albuminoids,	5.54	20.85	12.5
Non-albuminoids,	0.28	1.04	4.7
Crude fiber,	4.85	18.25	20.0
Nitrogen-free extract,	11.81	44.39	48.5
Fat,	1.69	6.24	4.0
	100.00	100.00	100.0

The grass, as shown by these results, is very rich in protein, and contains comparatively little crude fiber. In the dry state it resembles

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the grains in composition more nearly than it does the ordinary coarse fodders. Of the total amount of nitrogen found in the grass only 4.98 per cent. was found to be in a non-albuminoid form, the remainder being, so far as our means of analysis can show, in the form of true protein. In the table we have compared the results of our analyses with the average of German analyses of pasture grass, as given by Wolff. Our samples were taken at an earlier stage of growth than most of those represented by Wolff's average, and consequently we find in our average considerably more protein and somewhat less crude fiber; otherwise there is no very marked variation between the two, except that the proportion of non-albuminoids is much larger in Wolff's average.

DIGESTIBILITY.

We were not able to make any direct determination of the digestibility of the grass cut from this plot. In the experiment upon the value of green as compared with dry grass, which is reported below, the digestibility of the grass was determined. This grass was cut at a rather later stage of growth than the pasture grass of this experiment, and hence was presumably less digestible. The following is a summary of the results obtained:

Digestion Co-efficients of Pasture Grass.

Dry matter,	70.01
Ash,	52.66
Albuminoids,	59.37
Non-albuminoids,	[100.00]*
Crude fiber,	75.51
Nitrogen free extract,	72.71
Fat,	57.48

*Assumed to be highly digestible.

These results are probably somewhat too low for grass of the composition found in this experiment, but for want of better results they have been made the basis of comparison.

YIELD PER ACRE.

From the data given above, we can compute the rate of yield per acre of our plot, both of green grass, of dry matter, and of the various ingredients of which that dry matter is composed. Before presenting the results of this calculation, however, it seems desirable to say a word as to the value of the results thus reached. The term pasture has a very wide range of meaning. It may be applied, as it often is in New England, for example, to a rough, rocky hillside which is used as pasture, because no other use can be made of it. At the other extreme stand the rich lowland pastures of northern Europe, which furnish a great abundance of feed, and are regularly used for the fattening of cattle. Between these two extremes we may have

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all degrees of productiveness. Furthermore, the yield of the same pasture will vary according to the season. It is evident then that no single result like this can be said to represent the yield per acre of pasture. In the nature of things, it is impossible to find what is the yield per acre of pasture in general. Our results show what was produced under a certain set of circumstances. The sod upon our plot was rather thin; the rainfall was greater than the average, except during June, when it was notably deficient.

On the other hand the rainfall was less evenly distributed than usual, the number of days on which rain fell being less than the average, with the exception of April, May and October.

	TOTAL RAINFALL.—INCHES.		NO. OF DAYS ON WHICH RAIN FELL.	
	1880-84.	1888.	1880-84.	1888.
April, . . .	1.93	2.79	8	10
May, ...	4.23	6.26	12	17
June, . . .	4.70	2.61	12	7
July, . . .	2.41	2.78	10	6
August, . .	2.83	6.16	8	6
September,	2.21	3.12	7	4
October, . .	2.34	3.76	8	13

Furthermore, the grass was probably kept cut too close to fairly represent good pasture not too heavily stocked. In a repetition of the experiment, I should consider it desirable to cut much less frequently. Taking the results as they stand, and for what they are worth, we find the total yield of green grass per acre, from the beginning of the season to October 30th, to have been 4,276.82 lbs., and that this amount of green grass contained 1,145.49 lbs. of dry matter. The following table shows the yield of each separate ingredient of the fodder. The digestibility of the several ingredients has been computed by the use of the digestion co-efficients given above.

Total Yield in Pounds per Acre up to October 30, inclusive.

Total fresh matter, ...	4,276.81
Total dry matter, ...	1,145.49
Ash, ...	106.66
Albuminoids, ...	238.63
Non-albuminoids, ...	12.37
Crude fiber, ...	207.03
Nitrogen free extract, ...	509.40
Fat, ...	71.40
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Albuminoids, ...	160.42

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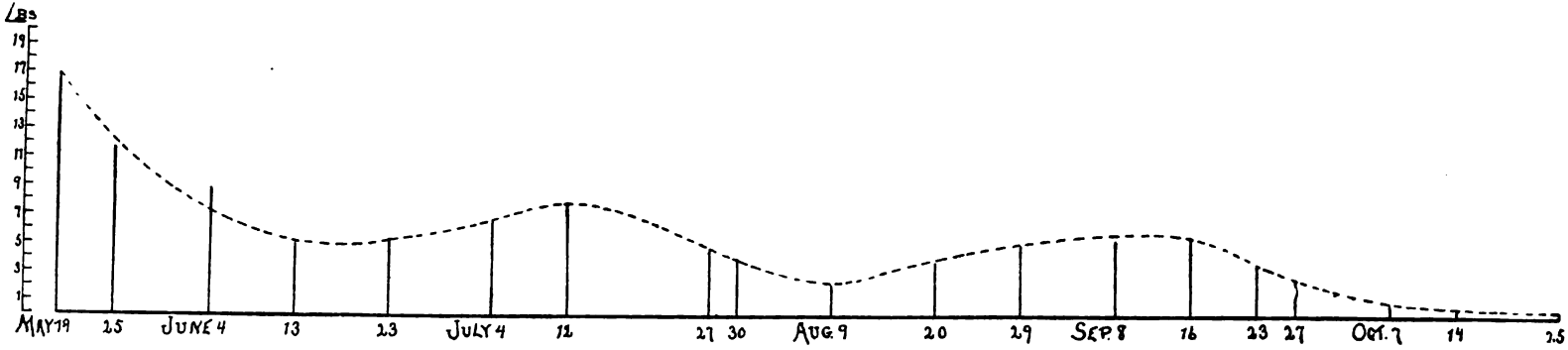

RATE OF GROWTH OF PASTURE GRASS.

PLATE III.

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Non-albuminoids,	12.37*
Carbhydrates, fiber and nitrogen free extract,	529.64
Fat,	40.69

RATE OF GROWTH.

The above figures show the total yield per acre throughout the season. It is desirable to know also the daily rate of growth at different times. In the first period it is plain that we must assume a date when the growth began since the yield obtained at the first cutting represents the total growth up to that time. In the following table it has been assumed to represent the growth of twenty days. In the subsequent periods each number represents the average of the 7 sub-plots. The date given is found as follows: The date of cutting the first sub-plot and the date of the last previous cutting of the same sub-plot being known, the number of days between these two dates gives the number of days growth represented by the yield of that plot, and a date half way between the two dates given above would be the one to which the average rate of growth might be assigned. By going through the same calculation with each of the seven sub-plots, and averaging the results, we get the number of days growth represented by the yield of the 7 sub-plots, and the date to which the average rate of growth is to be assigned.

Average Daily Growth. Pounds per Acre.

PERIOD.	Average date of cutting.	Total dry matter.	Total digestible matter.
1,	May 19,	16.95	11.04
2,	" 25,	11.68	7.60
3,	June 4,	9.09	5.88
4,	" 13,	5.00	3.22
5,	" 23,	5.67	3.69
6,	July 4,	5.92	3.83
7,	" 12,	7.17	4.64
8,	" 21,	4.71	3.05
9,	" 30,	4.22	2.80
10,	Aug. 9,	2.13	1.40
11,	" 20,	3.80	2.46
12,	" 29,	4.90	3.20
13,	Sep. 8,	5.32	3.45
14,	" 16,	6.71	4.35
15,	" 23,	3.51	2.28
16,	" 27, [3 plots],	2.56	1.63
17,	Oct. 7, "	0.65	0.41
18,	" 14, [6 plots],	0.62	0.39
19,	" 25,	0.44	0.28

The diagram given herewith represents to the eye the variation in the rate of growth at different times during the season, the length of the vertical black lines being proportional to the daily rate of

* Assumed to be wholly digestible.

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growth at the several dates. It is evident both from the table and the diagram that there was a rapid falling off after the early spring growth, doubtless exaggerated somewhat in this case by the dry weather of June, and possibly by the too frequent cutting. Still the results are such as might be reached on fully stocked pasture. The point most worthy of notice is the great variation in the yield at different times, it being from five to eight times as great in early spring as in August. The result of this is that if a pasture is stocked to its full capacity in the spring, it is over-stocked in midsummer, and both the pasture itself and the yield of the herd suffer. On the other hand, if only so much stock is placed on the pasture as it can carry throughout the season, the early spring growth is not utilized. The only way in which this difficulty can be overcome is by supplementing the pastures with other feed during the summer, either in the form of soiling or of grain feed.

It is difficult to state what was the average daily yield in this experiment, owing to the uncertainty as to what should be considered the length of the season. If, however, we assume that the grass was fit to pasture on May 10th, and reject the very small yields after September as of no account, we have the season extending from May 10th to September 29th, or 142 days. During this time, the average daily growth was as shown below:

Average daily growth for whole season.—Pounds per acre.

Fresh grass	25.17
Total dry matter	7.70
Ash	0.71
Albuminoids	1.61
Non-albuminoids	0.08
Crude fiber	1.41
Nitrogen free extract	3.42
Fat	0.48
Digestible.	
Albuminoids	1.08
Non-albuminoids	0.08
Carbhydrates (fiber and nitrogen free extract)	3.57
Fat	0.27
Total digestible organic matter	5.00

NUTRITIVE VALUE OF PASTURE GRASS.

BY H. P. ARMSBY AND WM. H. CALDWELL.

In the experiment just reported data were obtained as to the gross yield per acre of pasture. In order to be able to estimate accurately

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the value of pasture, however, we need to know the digestibility of the product as well as its total amount. In the discussion contained in the foregoing paper, we have anticipated the results of the experiments upon this point, now to be reported. It was at first attempted to carry out a digestion experiment upon grass similar to that growing upon the plots used in the previous experiment. At first the clippings obtained from the college campus by the horse lawn mower were used. Later, owing to the comparatively slow growth of the grass, and the difficulty experienced in securing a sufficient quantity in this way, spots were selected upon the campus on which the grass was sufficiently long to be cut with the scythe, although still comparatively young. This grass, of course, differed considerably in composition from the very young grass cut from the plots, and was presumably somewhat less digestible, but it was as close an approximation to pasture grass as the circumstances permitted us to obtain. The opportunity offered by this experiment to study also the effect of drying upon the composition and value of the grass was utilized.

The general plan of the experiment and the discussion of the results are the work of the Director; the execution of the plan is to be credited to Mr. Caldwell, and the chemical analyses of fodders, dung and milk were made by Messrs. Patterson, Holter and Sweetser.

Effect of Drying.

There is a prevalent impression among farmers that drying diminishes very materially both the digestibility and feeding value of grass or clover. This impression arises very naturally from the comparison, which is forced upon every farmer, of the relative value of dry hay and pasture. While upon good pasture animals will thrive and produce abundantly of either milk or meat, the same animals when fed upon hay fail to yield anything like the same return.

When, however, exact digestion experiments came to be made, it was found that simple drying had practically no effect upon the digestibility of grass or clover. It is hardly necessary here to cite examples of this. The experiment has been repeated so often that every one conversant with the subject has been forced to admit that the simple drying of fodder without loss does not decrease its digestibility. It is still claimed, however, that while the dried material may be just as digestible as the green, the digested matter has not the same nutritive value. The ardent advocates of ensilage especially have claimed a greater nutritive value for this feed on account of its succulence, and have claimed that in the process of drying the nutrients of green food undergo a process of dehydration which renders them less easily digestible and less valuable, and in this connection they lay considerable stress upon the difference between hay and grass, noted above, and which is familiar to every one, as a further example of the value of succulence.

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While numerous comparative digestion experiments have been made on green and dried fodder, there have not been made, so far as I know, any exact experiments designed to test the truth of this general impression of the greater nutritive value of green as compared with dried material. The experiments described on the following pages were designed as a beginning in this direction. Owing to the great amount of labor and time requisite for the proper carrying out of such an experiment it was found impossible to use more than one animal. A larger number would doubtless have added to the value of the experiment, but the results are presented here for what they are worth.

PLAN OF THE EXPERIMENT.

The animal used was a five-year old Guernsey-Jersey cow. She dropped her second calf on April 2d, 1888. The week previous to entering upon the experiment her average daily yield of milk was twenty-nine pounds and three ounces. On May 11, 1888, she was fed ten pounds of the green grass, and the quantity of grass increased and that of dried fodder decreased until May 27th, when she was fed exclusively green grass, of which she received a full ration of eighty pounds. The experiment proper began on the afternoon of May 29th, and was conducted as follows: On the afternoon of each day there was cut on the College campus somewhat more than 165 pounds of grass. The grass was raked up carefully as fast as cut, placed in a cart and kept covered to prevent wilting, and taken to the barn as soon as the whole quantity had been cut. There a sample of five pounds was first taken for chemical analysis; then eighty pounds were weighed out for the animal, about half being given to it the same night, and the remainder kept covered in as cool a place as possible and used for the next morning's feed. Finally a second portion of eighty pounds was weighed out and spread on a large sheet to dry. It was at first attempted to dry this grass in the sun, but this was found to progress so slowly that as a substitute a staging was built over the boiler of the Mechanic Arts' shop, and the sheet containing each day's grass was spread out upon this and allowed to lie usually for nearly twenty-four hours. When thoroughly dried the whole amount for one day was carefully transferred to a cloth bag, tied up securely and set aside. This routine was gone through with daily throughout the first period of eighteen days. During the last five days of this period the digestibility of the grass was determined in the method described below. The weight of the cow and the amount of water drunk daily were determined; the cow was not allowed to run in the yard, but kept in the stable all the time. In the second period of the experiment, also extending over eighteen days, the dried grass from the previous period was fed, the grass dried on the first day of the first period being fed on the first day of the second period and so on

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throughout. The digestibility of the dried grass was determined during the last five days of the period, and the weights of animal and water drunk were taken as before. Throughout the experiment the animal was milked twice daily. Each milking was weighed and a sample of the night's and next morning's milk was taken daily for analysis. The feed given was eaten clean except on five days of the green grass feeding. Four of the days were in the first half of the period, and all five of them in what may be called the preliminary feeding; that is, there were no uneaten residues during the digestion period. After making allowance for these uneaten residues, we find the amount of fresh grass actually eaten per day in period I to have been:

First half,	79.05 lbs.
Second half,	79.75 "
Whole,	79.40 "

It should be observed that in an experiment conducted in this way practically all the errors of experiment are likely to diminish rather than to increase the comparative value of the dried grass. The green grass was weighed out and fed directly with practically no chance for loss. The dried grass on the contrary had been handled considerably, and since it was not weighed after drying any accidental loss during the drying and necessary handling would diminish the amount of food eaten in the second period, and so tend to cut down the milk yield. It is believed, however, that no material loss of fodder occurred during the experiment.

COMPOSITION AND DIGESTIBILITY.

The following table shows the proportion of water and dry matter, and the percentage composition of dry matter of the grass that was used in the preliminary feeding and in the digestion period, and that left uneaten.

Composition of Grass.

	Preliminary feeding.	Digestion period.	Uneaten residues.
Water,	73.21	75.77	58.61
Dry matter,	26.79	24.23	41.39
	100.00	100.00	100.00
In 100 parts of dry matter:			
Ash,	10.31	10.92	10.47
Albuminoids,	13.44	11.74	13.25
Non-albuminoids,	6.29	3.43	4.68
Crude fiber,	24.33	27.92	24.92
Nitrogen-free extract,	41.12	41.73	41.62
Fat,	4.51	4.26	5.06
	100.00	100.00	100.00

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It will be observed that the grass used in the preliminary feeding was of rather better quality than that used in the actual digestion period, since it contained considerable more protein and considerably less crude fiber. It is altogether probable that there was a difference in the digestibility corresponding to this difference in composition, and that more food was actually digested from the grass during the first part of the experiment than the figures to be presented later appear to show. On the other hand, however, this difference affects both periods of the experiment equally, since grass of the same quality was fed at a corresponding time in each period. By this method of conducting the experiment, therefore, we eliminate from the comparison of the nutritive effect, any error due to the varying composition of the grass on different days.

As noted above, the digestibility of the fodder was determined in both periods. The general method of conducting a digestion experiment is easily understood. A carefully weighed quantity of food of known composition is fed. This being known, we can calculate how much of each crude nutrient is eaten. After the feeding has been continued for a sufficient length of time so that all residues of previous fodders have been eliminated from the animal, the dung is collected carefully for several days, weighed and analyzed. From the data thus obtained, we can compute how much of each crude nutrient passes through the animal undigested. The difference between this amount and the amount eaten shows the amount digested. Much care is requisite in the details of such an experiment, but the general principle is easily comprehended from the above statement.

Without occupying space with the detailed figures of the digestion experiment, its general results are presented in the table below, which shows the percentage digestibility of the fodder. By this is meant that for example in period I, 68.7% of all the dry matter which the animal ate was digested and did not appear in the excreta; that of the total amount of protein contained in the feed of the first period, 65.5% was digested and so on with the other ingredients.

Percentage Digestibility.

PERIOD.	Fodder.	Dry matter.	Ash.	Total protein.	Albuminoids.	Crude fiber.	N. free extract.	Fat.
I, ...	Green grass,	68.7	49.7	65.5	55.5	74.3	72.5	54.7
II, ...	Dried grass,	71.3	55.5	71.5	63.2	76.7	72.9	60.1

The results just given show an apparently greater digestibility for the dried than for the green grass. A portion of this difference may arise from the method in which the experiment was conducted as will appear from the following considerations. If any of the grass was lost during the process of drying, the amount of material actually fed

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in the second period was less than that in the first period. In the computations as to the digestibility, however, it is assumed that the same amount of material was fed in the two periods. If this is not the case, the amount excreted in the dung in the second period, as actually determined, being deducted from a greater amount than was actually fed, will show a corresponding greater digestibility. It is reasonably certain, however, that not all the difference in the two sets of figures is due to this cause. In order to produce the observed difference in the digestibility of the dry matter, it would have been necessary that fully 20 per cent. of the grass should have been lost on drying. It is impossible that any such loss as this can have taken place, and most of the difference must be explained in some other way. On the other hand it is difficult to imagine that the drying can have actually increased the digestibility, and I am inclined to consider the observed difference as simply accidental and most probably due to variations in the amount of dung excreted. The results at any rate, agree with those of other experimenters in showing no loss of digestibility as the result of drying.

NUTRITIVE EFFECT

The nutritive effect of the feeding is to be measured by the gain or loss in weight of the animal and by the milk yield.

Live Weight.—The average live weight of the animals in the first and second period is presented in the following table which contains also the average amount of water drunk per day and the average stall temperature:

	Average Live weight.	Average water drunk.	Average stall temperature.
Period I. Green grass.			
First half, ...	763 lbs.	67.5 lbs.	67.9 deg. Fahr.
Second half, ...	783 "	54.2 "	71.8 " "
Whole, ...	773 lbs.	60.9 lbs.	69.9 deg. Fahr.
Period II. Dried grass.			
First half, ...	728 lbs.	106.1 lbs.	78.1 deg. Fahr.
Second half, ...	742 "	106.9 "	68.4 " "
Whole, ...	735 lbs.	106.5 lbs.	73.30 deg. Fahr.

In order to show better the variations of live weight the weights from day to day have been represented on the accompany diagram, in which the heavy line rises or falls as the weight increased or decreased. It is evident from the figures for the daily weighings and from an inspection of the diagram that while the weight of the animal was decidedly less in the second period, on the dried grass, than in the first period, the falling off of weight in passing from the one period to the

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other was a sudden one. Within three or four days after the dried grass feeding was begun, the weight practically reached its minimum and thereafter increased rather than decreased. If the apparent loss of weight in the second period had been due to deficient nutrition, we should expect that the falling off would be gradual. The fact that it was not indicates pretty conclusively that the loss was not due to actual decrease in the weight of the tissues of the animals, but to a decrease in the contents of the stomach and intestines due to the change of food. This appears so plain from the diagram that I believe we are safe in assuming that the green grass showed no material superiority over the dried grass, so far as the maintenance of the animal was concerned.

Quality of Milk.—The average percentage composition of the milk produced in each half of each period is shown below:

Percentage Composition of Milk.

	Total solids.	Fat.	Protein (Nx6.25).
Period I.—Green Grass.			
First half,	12.84	4.10	2.76
Second half,	12.29	4.19	2.80
Whole,	12.57	4.14	2.78
Period II.—Dried Grass.			
First half,	12.07	4.17	2.65
Second half,	12.27	4.27	2.58
Whole,	12.17	4.21	2.62

The table shows slight changes in the composition of the milk, but they are rather favorable than otherwise to the dried grass. The percentage of solids decreases somewhat regularly until the second half of the dried grass period when it again rises. The fat shows an increase, although a somewhat irregular one throughout the experiment, and the protein a decrease after the first half of the first period. On the whole the differences are so small as to be of little significance.

Quantity of Milk.—The table below shows the average daily yield of milk in each half of each period, and also the average yield per day of total solid matter, of fat and of protein, calculated from the composition of the milk as just given.

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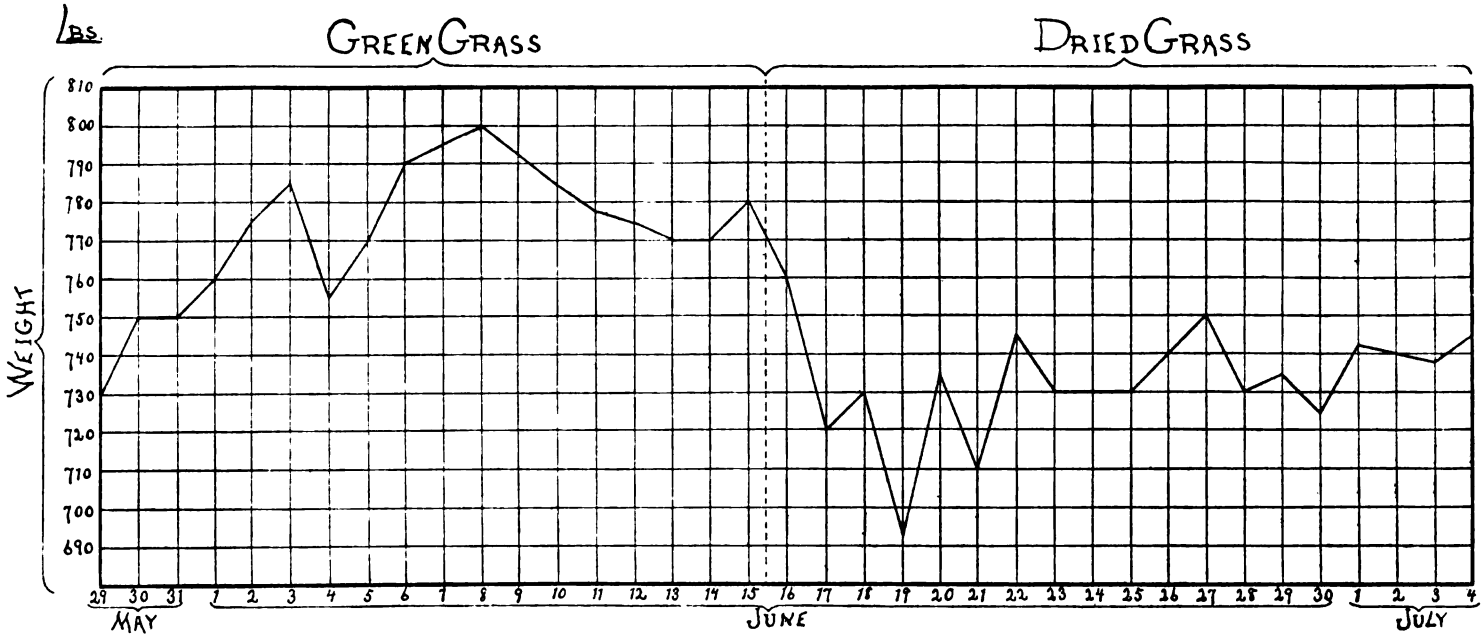

LIVE WEIGHT.

PLATE IV.

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Average Daily Yield.

	Fresh milk.	Total solids.	Fat.	Protein (Nx6.25).
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Period I.—Green Grass.				
First half,	26.17	3.36	1.07	0.72
Second half,	25.85	3.18	1.08	0.72
Whole,	26.01	3.27	1.08	0.72
Period II.—Dried Grass.				
First half,	25.27	3.05	1.05	0.67
Second half,	25.27	3.10	1.08	0.65
Whole,	25.27	3.07	1.06	0.66

The quantity of fresh milk produced per day decreases in general throughout the first period and the first half of the second period. During the second half of the dried grass feeding this falling off is arrested although no increase is produced. It is well known, however, that the proportion of water in milk may vary more or less from day to day, and hence the amount of total solid matter produced per day is a more accurate measure of the effect of the food than the amount of fresh milk. Taking the solids as our basis of comparison we find that between the first half and the second half of the first period the daily yield decreased .18 pounds; between the second half of the green grass period and the first half of the dried grass period it fell off .13 pounds, while between the first half and the second half of the dried grass period we note an *increase* of .05 pounds. The daily yield of fat is a matter of some interest since it furnishes us an approximate measure of the amount of butter which the milk might have produced. As will be seen, the yield of fat is very nearly uniform throughout the experiment, there being but a slight falling off in the first half of the dried grass period. The yield of protein is less in the second period than in the first. On the whole the figures appear to show a slight increase in the milk production in the last half of the dried grass period, although the differences are small. If they are to be accepted as significant we may say that the nutritive effect of the dried grass was slightly greater than that of green grass. It is to be remembered, however, that a little of the green grass was left uneaten in the first period while the dried grass in the second period was eaten clean so that the cow really received a trifle more food in the second period than in the first. Taking this into account, a fair calculation from the above results would appear to be that the green grass and the dried grass were substantially equal in nutritive effect. It was not possible in this experiment to determine the actual yield of butter from the milk. The amount of fat contained in the milk may, of course, be taken as an approximate measure of this, but, as will be shown below, this measure is not an exact one. The churnability of milk, that is

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the proportion of its total fat, which can be recovered in butter may vary considerably, it would appear, under the influences of the food eaten. Further mention on this point will be made in connection with the experiment about to be described.

Experiment at the Agricultural Experiment Station of the University of Wisconsin.

During the summer of 1887 the writer carried out an experiment very similar to the one just described, at the above institution, with which he was then connected. In this experiment the grass used was considerably more mature, being cut when some nine or ten inches high. No determinations were made of the digestibility of the grass, but, on the other hand, the amount of butter produced from the milk of the cow was determined and its quality passed upon by an expert. An unfortunate mistake also diminished somewhat the value of the experiment. It was the intention to make grass the sole feed of the cow, but by a misunderstanding of orders the cow was fed wheat bran by measure like the rest of the herd. When the mistake was discovered about the end of the first period the man was directed to measure out the customary amount of bran and place it on the scales. This was repeated three times and, the three weighings agreeing closely, their average was taken to represent the amount of bran which had been fed, and throughout the rest of the experiment this amount was weighed out daily to the cow. The amount of bran fed per day was 5.5 pounds. The cow used in the experiment was a grade Jersey which had previously been used in the experiments on milk production described in the report of the Wisconsin Station for 1887. She was kept in the barn during the day, but was allowed to run in the yard during the night. She could not have found there, however, any material amount of food. The trial feeding began May 26. The actual experiment began June 2, the green grass period ending June 15 and the dried grass period June 29. The composition of the grass used was as follows:

Water,	76.28
Dry matter,	23.72
	100.00
In 100 parts of dry matter:	
Ash,	6.94
Protein,	14.47
Crude fiber,	29.20
Nitrogen—free extract,	46.14
Fat,	3.25
	100.00

The bran was not analyzed, since the amount fed was made as nearly as possible the same throughout both periods.

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NUTRITIVE EFFECT.

Live Weight.—The live weight of the animal was taken daily. The average of the daily weighings was as follows:

Period I. Green grass:
- First half, ... 885 pounds.
- Second half, ... 908 pounds.

Period II. Dried grass.
- First half, ... 929 pounds.
- Second half, ... 937 pounds.

There was a steady increase in the weight of the animal, slightly less rapid in the second period than in the first, but with not enough difference between the two to indicate anything like deficient nutrition.

Quality of Milk.—The composition of the milk in the several periods was as follows:

Average Percentage Composition of Milk.

	Total solids.	Fat.
Period I—Green Grass.		
First half,	14.13	5.15
Second half,	14.62	5.64
Whole,	14.36	5.40
Period II—Dried Grass.		
First half,	14.15	5.79
Second half,	14.36	5.44
Whole,	14.26	5.61

The figures vary somewhat, but so irregularly that they do not indicate any distinct effect of the variations in food on the composition of the milk. The average of the second period is nearly or quite as good as that of the first.

Quantity of Milk.—The quantity of milk produced is shown below:

Average Daily Yield. Lbs.

	Milk.	Total solids.	Fat.
Period I—Green Grass.			
First half,	17.32	2.45	0.89
Second half,	16.64	2.43	0.94
Whole,	16.98	2.44	0.92
Period II—Dried Grass.			
First half,	17.17	2.43	0.99
Second half,	18.45	2.65	1.00
Whole,	17.81	2.54	1.00

There was a slight falling off in the yield as between the first and second halves of the first period, except in the case of the fat. With these exceptions there was an increase of yield as the experiment progressed. It is remarkable that this experiment, like the one previously described, seems to show a slight gain as the result of drying, but even

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though the two experiments concur in this respect, I believe we are warranted in assuming this slight gain to be accidental and not due to the feeding. It is certainly difficult to conceive how drying the fodder should improve its quality, and in any case the two experiments afford insufficient data for such a conclusion. Both experiments coincide, however, in failing to show any loss as the result of drying. If there were any such marked difference between green and dried fodder as is sometimes claimed, it seems hardly possible that it should have failed to show itself in two experiments conducted on the whole as carefully as these.

Yield of Butter.—In this experiment each milking was, after being sampled, placed in a small Cooley can, and the cream produced, after proper ripening, was churned every three days. The butter was salted as usual, one ounce to the pound, but not colored. After weighing, a sample of about a pound was packed in a tin box, which was placed inside a wooden box, surrounded by grass, and shipped at once by express to a butter dealer in Chicago for rating according to the established scale of points. The following table shows the average yield of butter, and gives also the weight of pure fat contained in this butter. In this way, by taking the amount of fat in the butter as the basis of comparison, we may eliminate any errors due the varying amounts of water, salt, casein, etc., contained in the commercial butter.

Average Daily Yield of Butter. Lbs.

	Fresh butter.	Butter fat.
Period I—Green Grass.		
First six days,	0.88	0.72
Last seven days,	1.06	0.86
Whole,	0.99	0.79
Period II—Dried Grass.		
First six days,	0.94	0.79
Last nine days,	0.99	0.82
Whole,	0.97	0.81

The yield of butter is practically the same in the two periods, or if we make allowance for the slight variations in composition by making the yield of butter fat the basis of comparison shows a slight gain in the second period. It should be noted, however, that this slight gain in the second period is considerably less than corresponds to the increased amount of fat in the milk produced, as shown by the previous table.

Churnability of Milk Fat.—The fact just mentioned leads naturally to a consideration of the relation between the total fat contained in the milk and the amount of butter which can be made from it. Not all the fat of the milk can be converted into butter. A small portion of it in any case remains in the skim milk, and another, usually somewhat larger, portion in the buttermilk. It appears from numerous ex-

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periments that the food of the animal may influence to a considerable extent the proportion of the total fat of the milk, which can be recovered in the butter. It is plain, then, that if any particular food or method of feeding has the effect of causing the milk to churn better, or, in other words, enables us to get out of the milk a larger proportion of the fat which it contains, that food or that method of feeding is of special value to the buttermaker even though it does not produce any greater total amount of fat in the milk. The subject of the influence of feed on the churnability of milk has been comparatively little studied, but a few recent experiments go to show that the use of green succulent food enables us to separate the butter more completely from the milk.

Alvord * gives the following results of trials made at Houghton farm. The first table below shows the total amount of fat in the milk, the amount of fat in the butter obtained by churning the same milk, and finally the percentage of the total amount of fat in the milk which was recovered by the churn. The results show the average product of the same lot of cows fed first on hay and grain in April, second on ensilage and grain in March, and third on good pasturage in May. The second table gives similar data for a single cow "selected for the apparent uniformity of her product, and of her health, appetite and general condition." In the table as given the amount of butter fat obtained has been substituted for that of the butter obtained as given in the original paper, it being assumed that the butter contained eighty-five per cent. of fat. While it is not likely that this was exactly true, it is hardly possible that the variations in the composition of the butter could account for the differences observed.

Trial with Herd.

FOUND IN 100 LBS. OF MILK.	Dry-fed hay and grain in April.	Fed corn ensilage and grain in March.	On good pasturage alone in May.
Actual fat in milk, ...	5.12 pounds.	4.37 pounds.	4.13 pounds.
Butter fat obtained, ...	4.21 pounds.	3.71 pounds.	3.58 pounds.
Per cent. of fat churned out, . .	82.17 per cent.	84.80 per cent.	86.64 per cent.

Trial with Single Cow.

FOUND IN 100 LBS. OF MILK.	Fed hay and grain in March.	Fed corn ensilage and grain in March.	Fed corn ensilage alone in April.	Fed on grass alone pasturage in May.
Actual fat in milk, .	4.76 pounds.	4.42 pounds.	3.93 pounds.	4.64 pounds.
Butter fat obtained,	3.60 pounds.	3.73 pounds.	3.36 pounds.	4.04 pounds.
Per cent. of fat churned out, . . .	75.53 per cent.	84.43 per cent.	85.43 per cent.	87.02 per cent.

* Society for Promotion of Agricultural Science, 1883-1884, pages 23-24.

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Alvord's conclusion from the above results is that "the greater the proportion of succulent food, the more completely the churn will do its work." Experiments by Sturtevant,* in which the total fat of the milk was compared with that obtained by churning on a small scale, show very considerable variations in the churnability of the milk on different feeds, but the feeding periods were too short to allow any very definite conclusions to be drawn as to the exact effect of the feed in this respect. It is worthy of note, however, that with one exception the ensilage period gave the highest churnability. In our own experiment the proportion of the total fat which was recovered in the butter was as follows:

PERIOD I.—First half,	80.95	PERIOD II.—First half,	79.23
Second half,	91.18	Second half,	81.45
Whole,	86.64	Whole,	80.65

Here we have a difference of six per cent. in the churnability of the milk, or if we compare the second halves of the two periods, a difference of nearly ten per cent. in favor of the green grass.

In experiments upon the comparative value of cornfodder and ensilage, Woll † found that during the period in which ensilage was fed, the percentage of fat obtained in the butter was 12.60 per cent. greater than the average of the two periods in which cornfodder was fed.

His results were as follows:

	Butter fat.	Milk fat.	Churned out.
Period I, ...	11.59 lbs.	13.12 lbs.	88.35 per cent.
Period II, ...	11.05 lbs.	11.61 lbs.	95.15 "
Period III, ...	9.50 lbs.	12.38 lbs.	76.74 "

It would seem from these results to be highly probable that green succulent food does improve the churning qualities of milk, and that if, in the experiment described above, butter had been made from the milk, there would have been a gain in the first period as compared with the second.

Quality of Butter.—As noted above, samples of the butter from each churning were sent to a Chicago dealer for rating. The samples sent him were designated by number only, and he had no knowledge of the nature of the experiment in progress. The following is his letter, including his report on the samples:

"Please find enclosed score of the samples of butter sent me. You will see that I have made the score 50 points. The flavor, I presume, is what you most wanted. The examination made yesterday was made without any reference to the former score, and, of course, I have allowed a little in flavor for the stock being old.

I was quite surprised to find Nos. 4, 5 and 6 very rank in flavor.

*Report New York Agricultural Experiment Station, 1883–1885.

†Agric. Experiment Station, University of Wisconsin, Fifth report, page 52.

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The number 1 was quite oily. The others were about as ordinary butter is after being held.

This butter was put on a shelf on the side of my ice-box in my refrigerator, and I do not think the temperature varies much from 55, and I was surprised that the lots which I have named should get so badly off in flavor. I had my butter man make the score at the same time without knowing what the other man put down, and we run very close on points, and I have averaged them so I think they will be about right. There was none of it as high in flavor as some of the fine creameries which we receive, but I suppose it could not be done in making such small lots.

Yours truly,
A. H. BARBER."

The results on the fresh butter were as follows:

Green Grass Period.

No. of Sample.	MILK OF	Churned.	Flavor. 30.	Grain 10.	Color 5.	Salt 5.	Total. 50.
1, ...	June 3, 4, 5, ...	June 6, .	20	10	4	5	39
2, ...	June 6, 7, 8, ...	June 9, .	12	8	5	4	29
3, . . .	June 9, 10, 11, . . .	June 14,	22	9	4½	4½	40
4, ...	June 12, 13, 14, 15, .	June 17. .	20	8	4½	4½	37
	Average, . . .	. . . . .	18.5	8.75	4.5	4.5	36.25

Dried Grass Period.

No. of Sample.	MILK OF	Churned.	Flavor 30.	Grain 10.	Color 5.	Salt 5.	Total. 50.
5, ...	June 16, 17, 18, . .	June 20, .	18	7	4	3	32
6, ...	June 19, 20. 21, . .	June 23, .	14	8	3½	4	29½
7, ...	June 22, 23, 24, . .	June 27, .	16	10	5	4	35
8, ...	June 25, 26, 27, . .	June 30, .	21	10	5	5	41
9, ...	June 28, 29, 30, . .	July 2, .	20	10	3½	4	37½
	Average, . . .	. . . . .	17.8	9	4.2	4	35.0

On August 4 a second examination of the samples was made, they having meanwhile been kept in the ice box, with the following results:

Green Grass Period.

No. of Sample.	MILK OF.	Churned.	Flavor 30.	Grain 10.	Color 5.	Salt 5.	Total. 50.
1, ...	June 3, 4, 5, ...	June 6, .	10	10	5	5	30.0
2, ...	June 6, 7, 8, ...	June 9, .	15	10	4½	4	33.5
3, ...	June 9, 10, 11, . . .	June 14, .	8	10	5	4	27.0
4, ...	June 12, 13, 14, 15, .	June 17, .	5	10	5	5	25.0
	Average, . . .	. . . . .	9.5	10	4.9	4.5	28.9

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Dried Grass Period.

No. of Sample.	Milk of.	Churned.	Flavor 30.	Grain 10.	Color 5.	Salt 5.	Total. 50.
5, ...	June 16, 17, 18, . .	June 20, .	5	7	4	3	19.0
6, ...	June 19, 20, 21, . .	June 23, .	5	8	4	4	21.0
7, ...	June 22, 23, 24, . .	Juue 27, .	10	10	5	4	29.0
8, ...	June 25, 26, 27, . .	June 30, .	12	10	5	4½	31.5
9, ...	June 28, 29, 30, . .	July 2, .	16	10	4	4	34.0
	Average, . . .	. . . . .	9.6	9.0	4.4	3.9	26.9

Nos. 4, 5 and 6, rancid; No. 1, oily.

It will be seen that the differences between the two classes of samples were comparatively small, and, on the average, showed that the chief difference between the two was in the flavor, though even there the difference does not amount to a whole point. If we allow any significance to this slight difference, the general result of the comparison is that the butter from the green grass was slightly better at first than that from the dried grass, but did not keep quite as well. It appears doubtful, however, if these small differences have any significance whatever. It will be observed that the quality of none of the samples was very high. This was probably due, as Mr. Barber's letter suggests, to the fact that the butter was made in small lots, and therefore not under the most favorable conditions, and to the further fact that the single cow used had been in milk about seven months.

CONCLUSIONS.

The experiments described above, taken in connection with what is already known on the subject, lead to the conclusion that the simple drying of grass without loss does not diminish either its digestibility or its nutritive value, as a food for milch cows, with the single exception that dried food appears to influence unfavorably the churning qualities of the milk. In this connection, some explanation seems to be called for of the great difference between grass and hay, which was alluded to in the introduction to this article, the more so as a good deal of confusion appears to exist upon this point even in the minds of those tolerably well informed on such subjects. Pasture grass is better than hay, first because it is cut earlier, and is therefore of a better quality *per se*. It is a perfectly well established fact that the earlier grass is cut the greater is its percentage of protein, and the less its percentage of crude fiber, both of which circumstances give greater value to the young grass. As an example of this, we may cite analyses of hay cut at three different times from the same meadow.*

* Landw. Jahrb. 8, I Supplement, 54.

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Composition.

CUT.	Protein, per cent.	Crude fiber, per cent.	Fat, per cent.	Nitrogen-free extract, per cent.	Ash, per cent.
May 14, 1877, ...	18.97	24.70	3.42	43.91	9.50
June 9, 1877, ...	11.16	34.88	2.74	43.27	7.95
June 26, 1877, ...	8.46	38.15	2.71	43.34	7.34

But not only was the grass of a better quality as shown by analysis in the earlier cuttings, but it was more digestible as well. Digestion experiments upon these samples showed the following percentage of digestibility for the several ingredients:

Percentage Digestibility.

CUT.	Protein.	Crude fiber.	Nitrogen-free extract.	Fat.
May 14, ...	73	80	76	65
June 9, ...	72	66	62	52
June 26, ...	56	61	56	43

From the figures of these two tables we can compute the percentage of digestible matter in each of the three samples of hay, and thus bring out still more strikingly the differences in their value. The results are contained in the table below.

Percentages of Digestible Matter.

CUT.	Digestible organic substance.	Digestible protein.	Digestible crude fiber.	Digestible fat.	Digestible nitrogen-free extract.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
May 14, . . .	69.20	13.85	19.76	2.22	33.37
June 9, . . .	59.31	8.04	23.02	1.42	26.83
June 26, . . .	53.45	4.74	23.27	1.17	24.27

Second. Grass is better than hay because in the ordinary processes of making hay, there is considerable loss of material. The leaves and tender parts, which are especially valuable, become dry first and crumble off more or less before the stems are sufficiently dried.

In an experiment by Wolf, Funke and Kellner * the loss in the preparation of Lucerne hay, amounted to 7.13% of the dry matter, and the hay was inferior both in composition and digestibility to the product obtained by carefully drying the same material under con-

* Landw. Vers. Stationen, 21,425.

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ditions similar to those of our experiment. The results were as follows:

	Composition.		Digestibility.	
	Dried without loss.	Hay.	Dried without loss.	Hay.
Protein,	17.00	14.94	71	67
Crude fibre,	31.81	33.90	48	45
Nitrogen-free extract, Fat,	43.80	44.22	66	62
Ash,	7.39	6.94	29	23
	100.00	100.00		

COMPARISON WITH FEEDING STANDARD.

It is of interest to compare the amount of food consumed in this experiment with the feeding standard for milch cows as given by Wolff. Taking the average of the two periods as representing most fairly the amount of digestible matter consumed, we have the following comparison:

Rations per Day and 1,000 Pounds Live Weight.

	Our experiment.	Feeding standard.
Total dry matter,	18.09	24.00
Digestible protein,	2.73	2.50
Digestible carbhydrates,	13.30	12.50
Digestible fat,	0.64	0.40
Total digestible organic matter,	16.67	15.40
Nutritive ratio,	1:5.6	1:5.4

Our ration was somewhat heavier than that called for by the standard, but the proportion of the several ingredients was very nearly the same.

Digestibility and Nutritive Value.

The data already given in discussing the effect of drying upon the grass cover, the question of its digestibility and nutritive value pretty thoroughly, so that only a summary of them needs to be given here. The average percentage digestibility obtained was as follows:

Dry matter,	70.0
Ash,	52.7
Total protein,	68.5
True albuminoids,	59.4
Crude fiber,	75.5
Nitrogen-free extract,	72.7
Fat,	57.5

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Probably the best practicable measure of the nutritive value of the grass is the ratio of food to product, as shown in the following table:

Average of Whole Experiments.

	Total dry matter.	Total digestible matter.
Required to produce 1 part of milk,	0.7037	0.5291
Required to produce 1 part of milk solids,	6.105	4.275
Required to produce 1 part of fat,	18.09	12.67
Required to produce 1 part of protein,	28.00	19.61

Upon these figures and upon the results of the preceding experiment, we may base some tentative conclusions as to the value of pasturage, always remembering that no one spot of ground can represent all pastures and no one cow all herds. It is to be noted also that the proportion of protein in our pasture grass was considerably greater than in the grass used in this experiment, and that consequently a certain amount of digestible matter in the pasture grass would probably produce more milk than the same amount in the other grass. How great this difference would be, however, we have no means of estimating, and can only take the figures as they stand. On this basis one acre of pasturage would produce per day as the average of the season:

Milk, ... 9.45 pounds.
Butter, * . . . . . 0.39 pounds.

These results, as has already been pointed out, apply strictly only to this cow, and to this particular piece of grass land. Some further discussion on this point in relation to the economy of pasturage and soiling will be found on subsequent pages.

Digestibility of Soiling Crops.

By William Frear, William H. Caldwell, G. L. Holter and W. S. Sweetser.

In earlier investigations the writer stated the yield and changes of composition of the various soiling crops at different stages of development. The result of these investigations indicate that, as a whole, the crops from highly manured soil were not only greater in quantity, but better in quality than those obtained from less fertile soil. Attempts were then made to determine approximately the amount of digestible matter yielded by an acre of each of these crops. For this purpose

* On the assumption that the weight of butter produced from the milk, equals the total amount of butter fat contained in t.

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certain coefficients of digestibility obtained from German experiments were used.

Attention was, however, called to the fact that these coefficients were obtained by averaging the results of a number of digestion experiments that were often accepted without any reference to the age or other quality of the feeding stuff. But it is well known, that a variation of these conditions is usually accompanied by a variation in the digestibility; and these latter variations would probably be such as to present a more favorable showing for the soiling crops. It seemed therefore desirable to investigate the digestibility of the fodder grown under the highly favorable conditions maintained with soiling crops.

Before proceeding to a detailed statement of the investigations, attention is called to the meaning of the terms employed. While there are many distinctly different substances which possess nutritive value, we find that all these substances may be conveniently grouped into the following classes:

1. Water, which is naturally so abundant that it is easily obtained by all, and therefore, its feeding value may be overlooked in such an investigation as the present.

2. The fats or oils.

3. The fiber, which is composed of material forming the cell walls of plants, and which also includes the hard, woody material.

4. The nitrogen-free extract, a very important group, containing starches, sugars, gums and jelly-forming matter.

5. The protein, or albuminoids, which includes gluten, the dough-forming material of bread; fibrin, the principal constituent of meat; albumen, a principal constituent of eggs; casein, an abundant constituent in milk; and other equally important food materials. In common practice among food investigators, there is included in this group the *amides*, or non-albuminoids, a class of nitrogenous substances differing considerably from those just mentioned in their chemical and nutritive properties, but to which it has thus far been difficult to assign a definite value.

6. Ash, the material left when any food is burned to whiteness; this includes the lime, magnesia, potash, phosphoric acid, and other essential mineral constituents of foods.

A study of the nutritive effects of these different groups of constituents has shown that the true albuminoids alone possess, in addition to the uses of the other groups,—fats, fiber and nitrogen-free extract,—the power of flesh formation; so that, while the albuminoids may, with more or less economy, perform the functions of the other groups of organic nutrients, the latter cannot act in full measure as substitutes for the albuminoids. The nutritive effects of these different groups of substances being thus far different, it is essential that each should be represented in a ration in such proportion as to meet most exactly the needs of the animal, needs which differ accord-

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ing to the age, kind and condition of the animal and the purpose for which it is grown.

In determining the value of any food, there are three elements to be considered:

1. The chemical composition, or the proportion of these different groups of food materials present in the substance under consideration.

2. The digestibility of the food; by this is meant the proportion of the food which is dissolved in the digestive apparatus of the animal, and taken up into the circulation within its body. Since the nutritive functions of the different groups of substances of which foods are composed, differ in the manner above indicated, it is necessary not only to know what proportion of the whole food is digested, but also to ascertain the proportion digested of each of these several ingredients. These proportions are expressed in percentages, and the precentage that is digested of any constituent fed, as fat or fiber, is called its *coefficient of digestibility.*

3. It remains to determine the nutritive value. This element in the determination of food value differs from the other two, in that it is influenced to a very great degree by other conditions than those dependent upon the quality of the food. In other words, a food of given composition and digestibility may be used in such ways as to produce very different nutritive results. Nevertheless, within rather general limits, experience has shown that food must be given in certain quantities, and in mixtures such as to afford not only certain quantities but also certain proportions of the groups of nutrients previously named, in order that it may be used economically for any specific purpose —as for maintenance, for the production of flesh, fat, milk or wool, or for the growth of young animals.

It is with the second of these elements in determining the value of soiling crops, viz: The digestibility, that the investigations about to be described are concerned.

THE PLAN OF EXPERIMENT.

The general method of conducting a digestion experiment is easily understood. A carefully weighed quantity of food of known composition is fed. This being known, we can calculate how much of each crude nutrient is eaten. After the feeding has been continued for a sufficient length of time, so that all residues of previous fodders have been eliminated from the animal, the dung is collected carefully for several days, weighed and analyzed. From the data thus obtained we can compute how much of each crude nutrient passes through the animal undigested. The difference between this amount and the amount eaten shows the amount digested. Much care is requisite in the details of such an experiment, but the general principle is easily comprehended from the above statement.

For these experiments two grade Devon steers were used, two-year-

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olds, of about 700 pounds weight. Previous to the beginning of the experiment proper, these steers were fed with indefinite quantities of the material to be experimented upon, so as to displace from the alimentary canal the residue of all other foods which would interfere with the successful conduct of the experiment.

After this, the feeding of definite quantities was begun. It is best to use an amount near the minimum daily consumption of the animals after they have become accustomed to the food; otherwise complications are introduced, by the considerable residues which may be left uneaten, and by the greatly increased variation in the quantities of fodder excreted from day to day. Certain German experiments render it probable that the contents of the alimentary canal of cattle are completely changed in seven days at the most. On this basis the feeding of definite quantities was continued for one week before the collection of dung was begun. This last operation was carried on for five days, the urine being caught in a rubber bag, strapped to the steer, while the dung was caught upon shovels as it dropped, by the watchmen who were stationed with the animals night and day during this last period.

The food was cut, well mixed, and an aliquot portion taken for analysis each day, starting with the time when the feeding of definite quantities was begun. The latter precaution is necessary for the reason that the dung of any day probably represents the food of several preceding days, and where the crops are growing and changing in composition day by day, the failure to take this fact into account may introduce a very considerable error into the results. Hence, in these experiments the average composition of food, from the time when the feeding of definite quantities was begun up to the close of the period of dung collection, has been taken as the basis of calculation. Any material that the steers left in the manger or pulled over onto the floor, was gathered up, weighed and sampled for analysis.

The animals were weighed and watered upon the scales daily at noon, being kept in the stable during the rest of the time, upon a bedding of sawdust. The dung was weighed at the end of each succeeding twenty-four hours, and an aliquot portion taken for analysis.

The samples on being taken to the laboratory were quickly dried, and so stored as to prevent any material change before analysis.

In the conduct of these experiments the writer is to be credited with the planning and supervision, while he is indebted to Mr. W. H. Caldwell for the care of details of feeding and sampling, and to Messrs. G. L. Holter and W. S. Sweetser for the analytical portion of the work.

Rye.

When "soiling rye" is mentioned, such a crop is not meant as is obtained when rye is grown for grain, but one obtained by very thor-

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ough tillage, high manuring and thick sowing. Our practice is as follows: At successive intervals, from early September to the last of October, rye is sown at the rate of four bushels per acre upon ground which has been deep plowed, thoroughly cultivated with a spring harrow, and before plowing, covered with as much well rotted yard manure as can be plowed under. These sowings yield crops developing at several periods closely succeeding one another during the following May and early June. It is probable that the time of sowing and the date when the crop has attained a sufficient development to be fit for feeding, may vary several weeks either way, with the range of variation in the climatic conditions in this State. It is sometimes the practice to pasture the rye in the late fall, to cut it in the spring some time before the formation of heads, and then to use the second crop which springs up shortly after. If the heads are allowed to form before this first cutting, the growth of rye for the second crop will be very sparse and unsatisfactory in quality. It is the practice here, however, to cut the crop at a somewhat later date, at the time of the formation of the head, or shortly after, and to break the land for a soiling crop of a different kind for use later in the season.

After the preliminary feeding, in which the steers were gradually transferred from dry food to exclusive feeding on rye, the feeding of definite quantities was begun, the date being May 21st. Eighty pounds per day of the freshly cut rye was fed in two feeds to each steer. The collection of dung was begun May 28th at noon, and continued till June 2d.

COMPOSITION.

The rye was well advanced in maturity for soiling purposes when the experiment was begun, and before it was completed had become a little more mature than is desirable in practice. The samples taken on the different days of experiment from May 21st to June 1st were united for analysis, the results of which are as follows:

	In green substance.	In water-free substance.
	Per cent.	Per cent.
Moisture,	84.33	
Fat,	77	4.89
Fiber,	4.72	30.14
Nitrogen-free extract,	6.35	40.51
Protein,	2.50	15.99
Ash,	1.33	8.47
	100.00	100.00
Per cent. of total nitrogen in a non-albuminoid state,		50.48

These results are seen to agree very well with those obtained from

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earlier analyses. A large proportion of the nitrogen is present in a non-albuminoid form.

During the feeding of the rye the steers did not change appreciably in weight, but steer No. 2 was apparently in not quite as good condition as No. 1. The amount of water drunk was surprisingly small. The excretion of dung was more regular with No. 1 than with No. 2. The table below shows in detail the amounts of fodder fed, left uneaten and excreted undigested by each animal during the five days beginning with May 28th. The results are stated in ounces instead of pounds for convenience in comparison.

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Digestibility of Soiling Rye.

	Fresh food.	Water.	Water-free substance.	Fat.	Fiber.	Nitrogen-free extract.	Protein.	Ash.
Steer No. 1.	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*
Water drunk,	1,000	1,000	.....	.....	.....	.....	.....	.....
Rye fed,	6,400	5,397.12	1,002.88	49.04	302.27	406.27	160.36	84.94
Rye refused,	136.5	114.00	22.50	.69	8.23	9.56	2.27	1.75
Rye eaten,	.....	6,283.12	980.38	48.35	294.04	396.71	158.09	83.19
Dung excreted,	1,891.0	1,627.96	263.04	12.18	62.10	120.10	32.12	36.54
Rye digested,	.....	.....	717.34	36.17	231.94	276.61	125.97	46.63
Coefficients of digestibility (per cent.),	.....	.....	73.2	74.8	78.9	69.7	79.7	56.1
Steer No. 2.								
Water drunk,	0	0						
Rye fed,	6,400	5,397.12	1,002.88	49.04	302.27	406.27	160.36	84.94
Rye refused,	138.5	110.88	27.62	.88	10 48	11.49	2.73	2.04
Rye eaten,	.....	5,286.24	975.26	48.16	291.79	394.78	157.63	82.90
Dung excreted,	2,117.0	1,863.17	253.83	12.74	57.16	112.91	33.71	37.31
Rye digested,	.....	.....	721.43	35.42	234.63	281.87	123.92	45.59
Coefficients of digestibility (per cent.),	.....	.....	74.0	73.6	80.4	71.4	78.6	55.0
Mean coefficients of digestibility,	.....	.....	73.6	74.2	79.6	70.6	79.1	55.5

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The statement of digestibility in the above table has been made for the sake of comparison with certain German results obtained before the distinction between albuminoid and non-albuminoid nitrogen was so clearly drawn as it is to-day. A fairer idea of the relative digestibility of the true albuminoids may be obtained from the following table, in the calculation of which the non-albuminoids are assumed to be wholly digestible, and are, for convenience in comparison, represented by 6.25 times their content of nitrogen, just as the albuminoids are.

	Albuminoids.	Non-albuminoids.
Steer 1.	*Ounces.*	*Ounces.*
Fed,	75.12	82.97
Excreted,	32.12	. . .
Digested,	43.00	82.97
Coefficients,	57.25 per cent.	100.00 per cent.
Steer 2.		
Fed,	74.92	82.71
Excreted,	33.71	. . .
Digested,	41.21	82.71
Coefficients,	55.00 per cent.	100.00 per cent.
Mean coefficients,	56.12 per cent.	100.00 per cent.

These figures show a very high degree of digestibility for soiling rye; much higher than those obtained for most coarse fodders. The German coefficients used in calculating the yield of digestible food per acre of soiling rye, as stated in the report for 1887, are those given by Julius Kühn,* which do not take into account the difference between albuminoid and non-albuminoid substances; they are as follows: of protein, 57 per cent.; of fat, 46 per cent.; and of nitrogen-free extract and fiber, quantities that together equal the total amount of nitrogen-free extract fed. These German figures assign a relatively low rate of digestibility to the fat and protein of fodder rye. It is seen from the results of our investigations that the crop obtained in the manner heretofore described, is far superior in value to the German crop; that not only do all the constituents possess a greater digestibility than that mentioned by Kühn, but the proportion of digestible protein to the other food constituents digested is considerably greater, thus making the relative proportions of these two classes of substances approach more closely those existing in pasture grass.

An attempt has been made to express the nutritive value of a food by the proportion of digestible nitrogenous matter, calculated as albuminoids, to a sum obtained by adding the amounts of digestible fiber and nitrogen-free extract to two and one-half times the amount of digestible fat, the fat having about two and one-half times as much

*Armsby's Manual of Cattle Feeding, p. 488.

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heat producing power as the constituents of the two groups associated with it in this ratio, which is called the *nutritive ratio.* These ratios, as ordinarily stated in papers on feeding, do not often, as yet, take into account the effect of the presence of non-albuminoids upon the digestibility and nutritive value of the protein. Weiske, from his experiments with sheep, assigned to pasture grass a nutritive ratio of 1:2.5. Results recently obtained at this station, and stated elsewhere in this report, show a nutritive ratio of 3.7 for rather mature pasture grass. Wolff states, as the results of numerous experiments, that 5.4 is the proper nutritive ratio of the food for milch cattle.

From our earlier investigations, with the use of Kühn's coefficients of digestibility, rye, in its earlier stages of growth, was given a nutritive ratio of 3.9, 55 per cent., of the total dry substance being considered digestible; while that taken at the last stage of maturity at which it was fitted for soiling purposes, was assigned a nutritive ratio of 1:6.5, 58 per cent. of the total dry substance being calculated as digestible. The figures from this digestion experiment indicate, however, that over 70 per cent. of the total dry substance is digestible, and that the material digested has a nutritive ratio of 1:4.8. In other words, the results indicate that soiling rye obtained from very fertile soil, when cut at the period of development when the head is about forming, possesses not only a much larger proportion than was formerly supposed, of material in such condition as to be available to the animal for milk production, but also that the constituents are present in such relative quantities as to fit the fodder for such use without the addition of other more concentrated nitrogenous fodders.

By the use of data obtained in this experiment, the yield per acre of digestible substances, as obtained in this year's crop, has been calculated. These results will be found in that portion of the report treating of the yield and nutritive value of soiling crops.

Clover.

This soiling crop was grown upon land which had been treated with large quantities of yard manure. The seeding was heavy, consisting of about six quarts of clover seed and two quarts of timothy per acre. The crop being first year's growth, the timothy constituted a very small proportion of the yield. The growth was very rank, and the clover had lodged and matted badly, and the stems were coarse. Owing to the delay caused by the necessity of preliminary feeding, and to the fact that clover, in our soiling rotation, is used to fill only a short interval, the material thus used was more mature than the average crop fed in practice. The heads had, in great measure, turned brown before the completion of the experiment.

In this experiment, owing to the rapidly advancing maturity of the clover, the preliminary feeding was shortened more than was desirable. The irregularity of excretion was, however, no greater than in

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the experiment with rye, so that it is probable that no serious disturbances could have resulted from the variations in the quantity of food fed during the preliminary period.

The feeding of the clover was begun June 2, at noon. The ration offered was sixty pounds per day, in two feeds, to each animal, until June 8, when it was increased to seventy pounds, and a further increase to eighty pounds was made on June 11. The collection of dung began June 11, and was continued for five days.

There was a little material left uneaten in several instances, but it consisted chiefly of foreign matter, and a very small proportion of old, hard clover stems, so slight in quantity as to be safely neglected.

COMPOSITION.

The average composition of the clover gathered from June 3 to 16 is as follows:

	Fresh substance.	Water-free substance.
	Per cent.	*Per cent.*
Moisture,	84.64	. . . . .
Fat,	.81	5.27
Fiber,	3.06	19.93
Nitrogen-free extract,	5.73	37.32
Protein,	3.43	22.29
Ash,	2.33	15.19
	100.00	100.00
Per cent. of total nitrogen in a non-albuminoid state,	. . . . .	10.59

As compared with Kühn's averages of German analyses of green clover, these figures show that the soiling clover had slightly more water and about the same proportion of protein and fat; but that it was strikingly deficient in nitrogen-free extract and fiber. The proportion of non-albuminoids is low for clover.

RESULTS.

As in the preceding experiment, there was practically no change in the body weight of the animals, and little water was drunk, though more than with rye. Here, too, the rate of excretion was more regular with No. 1 than with No. 2, the latter being slightly out of condition.

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Digestibility of Soiling Clover.

	Fresh weight.	Water.	Dry matter.	Fat.	Fiber.	Nitrogen-free extract.	Protein.	Ash.
Steer No. 1.	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*	*Ounces.*
Water drunk (June 11–15),	1,760	1,760						
*Clover eaten (June 11–15),	6,260	5,301	959	50.5	191.2	358.0	213.7	145.6
Dung excreted (June 11–15),	2,519	2,205	314	17.1	90.0	76.0	67.8	63.1
Clover digested,			645	33.4	101.2	282.0	145.9	82.5
Coefficients of digestibility,			67.3	66.1	52.9	79.2	68.3	56.7
†*Steer No. 2.*								
Water drunk (June 11–15),	1,360	1,360						
Clover eaten (June 11–15),	6,314	5,344	970	51.1	193.4	362.0	216,2	147.3
Dung excreted (June 11–15),	3,047	2,707	340	18.9	92.3	86.3	73.9	68.6
Clover digested (June 11–15),			630	32.2	101.1	275.7	142.3	78.7
Coefficients of digestibility,			64.9	63.0	52.3	76.1	65.8	53.4

*Since refuse matter was largely composed of sticks, etc., it was simply deducted from fresh weight.

†Slightly out of condition.

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Making a calculation of coefficients on the assumption that the non-albuminoid nitrogen is wholly digestible, the results would be as follows:

	True albuminoids.	Non-albuminoids.
Steer No. 1.		
Fed,	*Ounces.* 191.07	*Ounces.* 22.63
Excreted,	67.80	. . .
Digested,	123.27	22.63
Coefficients,	64.52 per cent.	100 per cent.
Steer No. 2.		
Fed,	195.3	22.9
Excreted,	73.9	. . .
Digested,	121.4	29.9
Coefficients,	62.16 per cent.	100 per cent.
Mean coefficients,	63.34 per cent.	100 per cent.

For comparison there are presented in the following table:

1. The mean coefficients of digestibility obtained in this experiment; Kühn's averages for
2. Green clover, just before blossoming;
3. Green clover, beginning to blossom;
4. Green clover, in full blossom;
5. Green clover, nearly out of blossom.

Digestion Coefficients.

	1.	2.	3.	4.	5.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total dry matter,	66.1	. . . .	. . . .	. . . .	. . . .
Fat,	64.5	62	71	63	45
Fiber,	52.6	55	56	48	39
Nitrogen-free extract,	77.6	76	77	70	71
Protein,	67.0	73	74	67	59
True albuminoids,	63.3	. . . .	. . . .	. . . .	. . . .
Ash,	55.0	. . . .	. . . .	. . . .	. . . .

Since the soiling clover used here was past the period of full bloom, it would represent a stage between 4 and 5; but its digestibility, especially as regards nitrogen-free extract and fiber, is greater than the average for clover in full blossom. As clover is seen, by the above table, to deteriorate rapidly with age, these results indicate a superiority on the part of the clover grown on highly fertile soil. It will be remembered, too, that this crop contained more nitrogen in proportion to the non-nitrogenous ingredients, than the average crop. Its nutritive ratio was 1:3.2. Wolf's standard for milch cattle being 1:5.4, it follows that to prevent waste of nitrogen, coarse fodders and grains deficient in this constituent should be fed with clover. The yield per acre of digestible matter has been calculated from these data, and is presented later in the report.

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Corn.

The method of raising soiling corn is as follows: The soil from which rye or clover has been cut is treated with about twenty two-horse loads of manure per acre. After plowing, the ground is thoroughly harrowed with a spring harrow, rolled, and then seeded down with four bushels of Dent corn, sown in drills three feet apart. The crop is frequently cultivated as long as it is possible. Feeding is begun when the stalk attains a height of four to five feet, and it is fed up as rapidly as possible after that time.

The corn used in this experiment was grown on the garden soiling plot. It was four or five feet high at the beginning of the feeding, but before the close had grown considerably, though it had not begun to harden. It was fully as young as would be fed in practice.

For several weeks prior to this experiment, the steers had been fed upon soiling corn from other plots. The feeding of definite quantities began on August 9, with eighty pounds. This amount was increased on August 12, to ninety, and on the 13th to one hundred pounds. During the whole experiment no residue was left uneaten. The period of dung collection continued from August 19, at noon, to the 24th.

COMPOSITION.

The samples taken from August 9 to 23, were put through the chopper before being carried to the laboratory, to allow more thorough sampling. The mean composition of these samples is shown in the following table:

	Green.	Water-free.
	Per cent.	*Per cent.*
Moisture,	90.04	. . . . .
Fat,	.40	3.98
Fiber,	2.70	27.14
Nitrogen-free extract,	3.92	39.32
Protein,	1.72	17.28
Ash,	1.22	12.28
	100.00	100.00
Per cent. of total nitrogen in a non-albuminoid form,	. . . . .	14.98

The average composition of maize fodder is stated by Jenkins * to be:

	Per cent.
Water,	86.90
Fat,	.20
Fiber,	4.10
Nitrogen-free extract,	6.50
Protein,	1.10
Ash,	1.20
	100.00

* Armsby's Manual of Cattle Feeding, p. 478.

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The soiling corn is seen to be more watery that the average fodder corn, and it contains more fat and protein and less fiber and nitrogen-free extract. A comparison with a number of analyses collated on page 124 of the report for 1887, shows that the differences between those crops and this were even greater than the early stage of development would lead us to expect. The extreme richness in protein must be attributed to the high fertility of the soil. The proportion of nitrogen in a non-albuminoid condition, was very low, considering the stage of development attained by the crop, and the fertility of the soil.

RESULTS.

No considerable changes in body weight were noted during the experiment. Steer No. 1, frequently drank water in considerable quantities; No. 2, took none after the first day. The excretion of dung was more regular with No. 2 then with No. 1. The detailed results are shown in the following table:

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Digestibility of Corn-fodder.

	Fresh weight.	Water.	Dry substance.	Fat.	Fiber.	Nitrogen-free extract.	Protein.	Ash.
Steer No. 1.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Water drunk (August 19–23),	22,679	22,679	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Corn-fodder eaten,	226,795	204,206	22,589	899	6,131	8,882	3,903	2,774
Dung excreted,	45,937	39,203	6,734	562	1,499	2,874	787	1,012
Corn-fodder digested,	. . . . .	. . . . .	15,855	337	4,632	6,008	3,116	1,762
Coefficients of digestibility,	. . . . .	. . . . .	70.2	37.5	75.6	67.7	79.9	63.5
Steer No. 2.								
Water drunk,	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
Corn-fodder eaten,	226,795	204,206	22,589	899	6,131	8,883	3,903	2,774
Dung excreted,	54,366	46,956	7,410	516	1,606	3,200	921	1,167
Corn-fodder digested,	. . . . .	. . . . .	15,179	383	4,525	5,682	2,982	1,607
Coefficients of digestibility,	. . . . .	. . . . .	67.2	42.6	73.8	64.0	76.4	57.9
Mean coefficients of digestibility,	. . . . .	. . . . .	68.7	40.0	74.7	70.8	78.1	60.7

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On the assumption that the non-albuminoids are wholly digestible. the results would be as follows:

	True albuminoids.	Non-albuminoids.
Steer No. 1.	*Grams.*	*Grams.*
Fed,	3,318	585
Excreted,	787	. . .
Digested,	2,531	585
Coefficients,	72.26 per cent.	100 per cent.
Steer No. 2.		
Fed,	3,318	585
Excreted,	921	
Digested,	2,397	585
Coefficients,	76.30 per cent.	100 per cent.
Mean coefficients,	74.28 per cent.	100 per cent.

For comparison there are presented in the following table:

1. The mean coefficients of digestibility obtained in this experiment.
2. The mean coefficients for very good green maize fodder obtained from European experiments.
3. The mean coefficients for corn stover obtained here in earlier experiments.

	Pennsylvania fodder, green.	German fodder, green.	Pennsylvania stover.
	Per cent.	*Per cent.*	*Per cent.*
Total dry matter,	68.7	. . .	62
Fat,	40.0	75.	52
Fiber,	74.7	72.	66
Nitrogen-free extract,	70.8	67.	64
Protein,	78.1	73.	52
True albuminoids,	74.3	. . . . .	42
Ash,	60.7	. . . . .	45

These figures show that the soiling corn from very fertile ground is highly digestible, especially as regards protein. The fat seems, in this case, to have been exceptionally indigestible, and very probably consisted largely of wax.

The nutritive ratio of this corn is 1:3 7. When it is recalled that the standard for milch cattle is placed by Wolff at 5.4, and that our experiments of 1887 assigned to well cured stover a ratio of 15, the remarkably high value of this young soiling corn for milk production is seen.

Summary.

The following tables are presented to permit the ready comparison of the composition and digestibility of the preceding soiling crops—rye, clover and corn—with that of pasture grass as determined by

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Armsby at this Station, and Weiske at Proskau; and with that of timothy hay, as determined by Jordan at the Maine station.

Composition.

	Rye.	Clover.	Corn.	Pasture.		Timothy hay.
				Armsby.	Weiske.	
Moisture,	84.33	84.64	90.04	73.37	.....	11.34
Water-free substance:						
Fat,	4.89	5.27	3.98	6.24	5.09	3.01
Fiber,	30.14	19.93	27.14	18.25	16.74	32.58
Nitrogen-free extract,	40.51	37.32	39.32	44.39	42.09	53.48
Protein,	15.99	22.29	17.28	21.89	27.07	6.70
Ash,	8.47	15.19	12.28	9.23	9.01	4.23
Per cent. of total nitrogen in non-albuminoid form.	52.48	10.59	14.98	4.82	.....	.....

Digestibility.

	Rye.	Clover.	Corn.	Pasture.		Timothy hay.
				Armsby.	Weiske.	
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total dry matter,	73.6	66.1	68 7	70.0	68.7	51.6
Fat,	74.2	64.5	40.0	57.5	*	55.0
Fiber,	79.6	52.6	74.7	75.5	67.3	42.8
Nitrogen-free extract,	70.6	77.6	70.8	72.7	76.8†	58.9
Protein,	79.1	67.0	78.1	68.8	77.4	45.2
True albuminoids,	56.1	63.3	74.3	59.37	....	...
Ash,	55.5	55.0	60.7	52.7	.....	.....
Nutritive ratio,	1:4.8	1:3.2	1:3.7	1:3.7	1:2.5	1:16.4

In comparing these data it should be remembered that the rye and clover were a little more, and the corn a little less, mature than is usual with these crops as fed. The pasture, too, was richer than that represented by the average of European analyses; that of Weiske being in all probability younger, and grown upon moister soil. The timothy hay was cut a couple of weeks past blossom.

Comparing the soiling crops with each other as regards composition, it is seen that the chief differences are in the content of protein and fiber, and that the crop containing the higher percentage of protein contains the less of fiber; for the crops, in the order of richness in protein are clover, corn and rye; but, in the order of fiber content, are rye, corn and clover. The digestion coefficients show, moreover, that even with crops of the same character but from different species, the chemical composition is not certainly indicative of the feeding value;

*Stated with nitrogen-free extract. †Includes fat.

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for of these crops, those having the greater quantity of fiber possess it in more digestible condition. Moreover, the same plants have their smaller proportion of protein also in a more digestible state than it is in the rich clover. Owing to the large proportion of non albuminoid nitrogen in the rye, the digestibility of the true albuminoids appears greatly reduced. The nitrogen-free extract or starch of the clover, seems more digestible than it is in the other crops.

Comparing these crops with pasture, it is observed that the latter, if it be of good quality, contains only a little more protein and fat than clover, and less fiber and more nitrogen-free extract than either of the soiling crops. The differences between the digestibilities of the different samples of pasture grass, are as great as those between pasture and any of the soiling crops. In general, it may be said that the pasture is slightly more digestible than the crops used for soiling purposes, and as a rule richer in nitrogen.

The deficiency of timothy hay in nitrogen and the comparatively low digestibility of its important nutrients, especially in the case of protein and fiber, are so prominent as scarcely to require mention.

Finally, a consideration of the nutritive ratios indicates more concisely the comparative values of these foods as regards their fitness in relative proportion of the several classes of nutrients, to serve for the purposes of milk production. Accepting Wolff's standard ratio for milch cattle, 1 : 5.4, both the soiling crops and pasture are seen to furnish a greater proportion of nitrogen than is necessary; therefore, the wisdom of the usual practice of adding hay and grains of a medium ratio to milk rations, is confirmed by the results of these experiments. Otherwise, there will result an excessive consumption of costly nitrogenous constituents without a corresponding gain in product. Because, however, of the great amount of dry matter in timothy hay as compared with pasture or soiling fodders, and because its nutritive ratio departs far more extremely to one side from the standard than those of the latter materials do to the other side, it is apparent that it will require no relatively great addition of hay to the green food to widen the ratio of the ration to the standard. If it is desired to utilize any considerable proportion of hay, it can only be done economically by the use of grains or grain products of narrow ratio, in addition to the soiling crops.

As a whole, then, these experiments show that the soiling crops are more highly valuable for milk production than any data previously at command warranted us in believing; so that, unless further investigation should disclose unfavorable dietetic effects, which there is now no reason to suspect, it may safely be concluded that as far as the materials themselves are concerned, they are equally as valuable as pasture grass for their purpose. As stated in another part of this report, there is no difference apparent in the composition of the milk produced with soiling crops and pasture; though no test has been

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made of relative churnability. But before any conclusions can be reached concerning the comparative economy of soiling and pasture systems under given conditions, there are questions to be settled concerning the cost of producing and handling the crops.

YIELD AND NUTRITIVE VALUE OF SOILING CROPS.

BY H. P. ARMSBY AND WM. H. CALDWELL.

As before stated, the object of this part of the investigation was to observe the system as actually practiced here. The information thus gained may perhaps be made the basis for future investigations and improvements in the system. The soiling crops used were rye, clover and corn. The interval between clover and corn has been hitherto filled up by the use of grass cut along the sides of the drives, and in various other places, but this was not made the subject of experiment. The crops mentioned above are grown on specially rich ground, heavily manured, in order to obtain the greatest possible yield, and to diminish the relative cost of cutting and hauling. Further details upon these points may be found in the preceding paper upon the digestibility of soiling crops.

The plan of the experiments originated with the Director, and the discussion of the results is also his work. The details of the experiment were cared for entirely by Mr. Caldwell, while the analytical work involved was performed by the Station's assistant chemists, Messrs. Patterson, Holter and Sweetser.

COMPOSITION OF SOILING CROPS.

The composition of any growing crop varies from day to day. No special analyses of the soiling crops were made in connection with these experiments, the computations which follow as to the yield of the several nutrients in the soiling crops being based upon the analyses made in connection with the digestion experiments described above. The following brief summary of these results is given here for convenience of reference:

Percentage Composition of Soiling Crops—Green.

	Water.	Ash.	Albuminoids.	Non-albuminoids.	Crude fiber.	N.-free extract.	Fat.
Rye, May 21-27, . .	85.13	1.38	1.13	1.58	3.99	5.96	0.83
Rye, May 28—June 1, .	83.53	1.27	1.21	1.06	5.51	6.73	0.69
Clover, June 3-10, . .	85.66	2.14	3.08	0.13	2.71	5.49	0.79
Clover, June 11-15, . .	83.62	2.53	2.74	0.90	3.44	5.95	0.82
Corn, Aug. 9-18, . . .	90.26	1.32	1.52	0.28	2.50	3.68	0.44
Corn, Aug. 19-20, . . .	89.81	1.12	1.40	0.24	2.92	4.15	0.36

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Percentage Composition of Dry Matter of Soiling Crops.

	Ash.	Albuminoids.	Non-albuminoids.	Crude fiber.	N.-free extract.	Fat.
Rye, May 21–27,	9.28	7.58	10.64	26.81	40.12	5.57
Rye, May, 28–June 1,	7.67	7.35	6.42	33.47	40.88	4.21
Clover, June 3–10,	14.92	21.49	0.89	18.89	38.27	5.54
Clover, June 11–15,	15.46	18.33	3.87	20.97	36.36	5.01
Corn, Aug. 9–18,	13.60	15.55	2.88	25.61	37.89	4.47
Corn, Aug. 19–23,	10.97	13.81	2.31	28.66	40.75	3.50

YIELD PER ACRE.

This, like the composition, varies from day to day. The soiling crops were cut twice per day, and the area cut was measured once in from 1 to 4 or 5 days, except in the case of the corn of which only two measurements were taken; the first, that of the area cut during the first four days of the feeding, and the other covering the remainder of the period. The soiling rye was from two different plots, of which the second was considerably the richer. The yield in pounds per acre at the several dates is shown in the table below:

Yield of the Soiling Crops.

RYE.	*Lbs. per acre.*
May 15–17,	15,680
" 18,	11,200
" 19,	12,230
" 20–21,	17,320
" 22,	9,541
Average of the first plot,	13,670
May 23,	13,850
" 24–25,	18,440
" 26–27,	15,450
" 28–31,	18,300
June 1–4,	25,980
Average of second plot,	18,660
Average of all,	15,890
CLOVER:	
June 4–8,	23,680
" 9,	31,280
" 10–12,	28,010
" 13–16,	28,110
Average,	26,650

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CORN:	
July 24–27,	23,420
" 28–Aug. 15,	16,900
Average,	17,890

Taking the average results per acre as the basis of computation, and the average of the two analyses of each crop, given above, as representing the average composition of that crop, we find the yield per acre of the several ingredients of these crops to have been as follows:

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Yield Per Acre of Ingredients of Soiling Crops.—Lbs.

	Total dry matter.	Ash.	Albuminoids.	Non-albuminoids.	Crude fiber.	Nitrogen-free extract.	Fat.	Digestible.			
								Albuminoids.	Non-albuminoids.*	Carbhydrates.	Fat.
Rye,	2,491	211	189	200	751	1,000	122	106	200	1,310	90
Clover,	4,094	622	816	93	816	1,522	216	515	96	1,614	139
Corn,	1,782	219	262	46	484	700	71	195	46	857	28

* Assumed to be wholly digestible.

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ANIMALS.

Seven cows were used for this experiment. As has been already noted, they were only very ordinary milkers, so that they are far from showing the best results that could be obtained with the soiling system.

FEEDING.

For the first week of the experiment, beginning May 8, the cows received as nearly as possible the same feed that they had been having up to that time, consisting of hay, bran and chop (about equal parts of corn and oats ground together). The first feed of the rye was given on the afternoon of May 15, and thereafter they received about half their total fodder in the form of soiling, the remainder consisting of hay and grain as before. The grain and hay were weighed out in advance in sufficient quantity to last for a number of days, and were fed to the cows in accordance with the judgment of the herdsman, he being instructed to feed as nearly as possible as he had been in the habit of doing in previous years. No attempt was made to ascertain the amount eaten by each individual cow. The amount of soiling fed was, of course, weighed twice daily immediately after cutting. The following table shows the amounts of the several fodders actually eaten per day and head. The last portions of hay and grain weighed out for the rye period were more than sufficient to complete that period, and the residues were not weighed but were simply carried over to the clover period, consequently the amounts of hay and grain eaten, as given in the table, are the average of these two periods, and may have varied somewhat in the single periods, although probably not very much.

Eaten per Day and Heads—Pounds.

	Chop.	Bran.	Hay.	Soiling.
Preliminary, May 8–15,	2.07	1.97	18.47	66.19
Rye, May 16–June 4,	2.64	2.40	5.74	69.52
Clover, June 4–16,				
Corn, July 24–Aug. 15,	2.57	1.67	5.56	83.09

Samples of the hay and grain used were taken at different times during the experiment and analyzed with the following results:

Composition of Grain and Hay.

	Water.	Ash.	Albuminoids.	Non-albuminoids.	Crude fiber.	N.-free extract.	Fat.
Hay,	14.00*	5.78	8.91	1.62	25.14	41.32	3.23
Bran,	10.95	11.00	14.40	3.10	4.81	51.56	3.58
Chop,	9.98	8.87	9.83	1.18	3.90	61.61	5.23

*Assumed as average water content.

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The composition and digestibility of the soiling crops has been already given. On the basis of these figures and assuming average digestibility for the hay and grain, we may calculate the composition of the daily rations:

Rations Eaten.—Pounds Per Head.

	Total dry matter.	Digestible.			
		Albuminoids.	Non-albuminoids.	Carbhydrates.	Fat.
Preliminary Feeding.					
2.07 lbs. chop,	1.86	0.16	0.02	1.09	0.09
1.97 lbs. bran,	1.75	0.21	0.06	0.81	0.05
18.47 lbs. hay,	15.89	0.81	0.30	7.38	0.29
	19.50	1.18	0.38	9.28	0.43
Period I.					
2.64 lbs. chop,	2.38	0.20	0.03	1.38	0.12
2.40 lbs. bran,	2.14	0.25	0.08	0.99	0.06
5.74 lbs. hay,	4.93	0.25	0.09	2.29	0.09
66.19 lbs. green rye,	10.38	0.44	0.87	5.46	0.38
	19.83	1.14	1.07	10.12	0.65
Period II.					
2.64 lbs. chop,	2.38	0.20	0.03	1.39	0.12
2.40 lbs. bran,	2.14	0.25	0.07	0.99	0.06
5.74 lbs. hay,	4.93	0.25	0.09	2.29	0.09
69.52 lbs. green clover,	10.68	1.34	0.26	4.21	0.36
	20.13	2.04	0.45	8.88	0.63
Period IV.					
2.57 lbs. chop,	2.32	0.19	0.03	1.35	0.11
1.67 lbs. bran,	1.49	0.18	0.05	0.69	0.04
5.56 lbs. hay,	4.78	0.24	0.09	2.22	0.09
83.09 lbs. green corn,	8.28	0.90	0.22	3.98	0.20
	16.87	1.51	0.39	8.24	0.44

For convenience of comparison the figures of the above table have been condensed into the shorter table which follows, showing the amount of total dry matter and of its several digestible ingredients which was eaten per day and head in the several periods. For comparison there is added in the last line of the table the German feeding standard for milch cows, calculated for animals weighing 850 lbs., which was about the average weight of these cows:

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Summary of rations eaten.—Pounds per head.

	Total dry matter.	Digestible.					Nutritive ratio.
		Albuminoids.	Non-albuminoids.	Carbhydrates.	Fat.	Total.	
Preliminary, . . .	19.50	1.18	0.38	9.28	0.43	11.27	1:6.6
Period I, ...	19.83	1.14	1.07	10.12	0.65	12.98	1:5.3
Period II, . . .	20.13	2.04	0.45	8.88	0.63	12.00	1:4.2
Period III, ...	16.87	1.51	0.39	8.24	0.44	10.58	1:4.9
German standard pr. 850 lbs. live weight.,	20.40	2.13		10.63	0.34	13.10	1:5.4

As will be seen, the ration varied more or less from period to period. but was in no case very greatly different from the feeding standard. In the rye period it was very nearly the same. In the clover period the amount of protein in the ration was greater and the amount of non-nitrogenous matter less than in the feeding standard, while in the corn period the ration was below the feeding standard in all respects. The total amount of digestible matter eaten was least in the corn period and greatest in the rye period. The proportion of protein in the ration was rather greater in the last two periods than is called for by the feeding standard. This, however, rather improves the quality of the ration than otherwise, the writer having shown by numerous experiments that the greater the proportion of protein in a ration. other things being equal, the greater is the amount of milk which it will produce.

YIELD OF MILK.

The milk produced by the cows under experiment was weighed immediately after milking, and an average sample was taken for analysis. In the table which follows are given the average yield of milk per day and head for each period and also the number of pounds of total solid matter, of fat and of protein contained in the milk:

Average Yield of Milk and its Constituents.—Pounds per Head.

	Total milk.	Milk solids.	Milk fat.	Milk protein.
Preliminary, ...	14.46	1.84	.60	0.44
Period I, ...	14.80	1.93	.64	0.46
Period II, ...	14.51	1.89	.63	0.42
Period III, ...	13.22	1.68	.60	0.41

COMPOSITION OF MILK.

The average percentage composition of the milk in each period was as follows:

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Average Composition of Milk.

	Total solids.	Fat.	Protein.
Preliminary,	12.75	4.15	3.01
Period I,	13.01	4.32	3.14
Period II,	13.01	4.32	2.92
Period III,	12.71	4.54	3.08

The quality of the milk, as measured by the percentage of solid matter, was slightly better in periods I and II than in the other periods, but the differences are slight and we may say, in general, that the variations in the feeding had very little influence upon the composition of the milk.

RATIO OF FOOD TO PRODUCT.

The quantity of food eaten having varied in the different periods, we may compute approximately the nutritive value of the food by calculating how many pounds of food were required to produce one pound of milk or butter in each period. We may make the basis of this comparison the total dry matter of the food or, what is probably preferable, the amount of digestible matter contained in the food. In the subjoined table both methods of calculation have been used. We were not able in these experiments to actually make butter from the milk, and consequently we cannot say exactly how much butter it might have yielded, but as an approximate measure of this amount, we may take the amount of fat contained in the milk. While in butter making we do not separate all the fat from the milk, the weight of the butter is increased by the amount of water and other ingredients besides fat which it contains, so that the weight of butter produced is frequently as great or even greater than the weight of fat in the milk. At any rate, we may secure in this way to a certain degree a comparison of of the several periods.

Required to Produce One Pound of Milk [with 12 per cent. of Solids.]

	Total dry matter.	Digestible organic matter.
Preliminary,	1.27	0.73
Period I,	1.24	0.81
Period II,	1.28	0.76
Period III,	1.21	0.76

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Required to Produce One Pound of Fat. [Butter?]

	Total dry matter.	Digestible organic matter.
Preliminary,	32.50	18.77
Period I,	30.98	20.28
Period II,	31.73	18.92
Period III,	28.09	17.04

YIELD OF MILK AND BUTTER PER ACRE.

The proportion of the total digestible matter of the ration which is furnished by the hay, the grain and the soiling crops respectively, was nearly the same in the different periods, with the exception of the preliminary feeding, and in this the proportion furnished by the grain was nearly the same as in the others. The exact figures are as follows:

Percentage of Digestible Matter Supplied by

	Hay.	Soiling.	Grain.
Preliminary,	77.91	....	22.09
Period I,	20.98	55.07	23.95
Period II.	22.71	51.40	25.89
Period III,	24.95	50.04	25.01
Average I, II and III,	22.88	52.17	24.95

While in the preliminary feeding the hay furnished fully three-fourth of the digestible matter of the ration, it furnished less than one fourth of it in the other three periods, the remaining half being supplied by the soiling crops. Nevertheless, we find, on reference to the last table, that the amount of digestible matter required to produce a pound of milk or of butter was not greatly different in the several periods, and considering the approximate nature of our estimates of digestibility it does not appear that there was any obvious gain from the introduction into the ration of green food. This conclusion is strongly confirmed by the results of the experiment with green and dried grass reported on previous pages. It would appear, then, that the soiling crops were valuable in proportion to the amount of digestible matter which they furnished, and we may therefore, properly credit them with a proportion of the milk production corresponding to the proportion of the total digestible matter which they furnish. On this basis we obtain the following figures for the amount of the milk, and of the milk fat [butter] produced by the soiling crops:

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Product Due to Soiling.—Pounds per Day and Head.

	Milk [with 12 per cent solid].	Milk fat [butter].
Period I,	8.83	0.35
Period II,	8.03	0.34
Period III,	7.00	0.30

Making allowance for the small amounts of soiling left uneaten, the soiling for one cow for one day was supplied on the average by the following areas:

Rye, ... 181.5 square feet.
Clover, ... 113.6 square feet.
Corn, ... 202.3 square feet.

From this table, and the one last given, we can calculate the amount of milk and of butter produced per acre of soiling crop. In order to make a perfectly fair comparison the yield of milk is calculated from the yield of milk solids, on the assumption that the milk contains uniformly 12 per cent. of solids and 88 per cent. of water.

Yield of Milk and Butter per Acre. Pounds.

	Milk.	Butter.
Rye,	2120	84
Clover,	3098	125
Corn,	1508	65

COMPARISON WITH PASTURE.

The above figures furnish a basis for the comparison of pasturage and soiling. We cannot, however, compare the yields as above given directly, because of the three soiling crops, we may grow either rye and corn or clover and corn on the same ground in one season.

Relative Areas Required for each Crop.—On the basis of the amounts of the several soiling crops actually eaten by the cattle the relative area of each required is approximately: Rye, 3; Clover, 2; Corn, 3. We may get this proportion by means of the following two course rotation:

	1st year.	*2d year.*
One-fifth of land,	Rye and corn.	Rye and corn.
Two-fifths of land,	Clover and corn.	Rye.
Two-fifths of land,	Rye.	Clover and corn.

Yield of Milk and Butter per Season.—From the figures given above for the amount of milk and butter produced by an acre of the several soiling crops, we can compute the yield of one acre of ground for one season under the above rotation as follows:

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	Milk.	*Butter.*
Three-fifths acre of rye,	1,272 lbs.	50 lbs.
Two-fifths acre of clover,	1,289 lbs.	50 lbs.
Three-fifths acre of corn,	905 lbs.	39 lbs.
Totals,	3,416 lbs.	139 lbs.

These figures show, of course, simply the results obtained with the particular cows under experiment, and are probably considerably lower than they should be with good stock. They may serve, however, as a basis for comparison with pasturage. The only comparison possible between the two, however, is on the basis of the yield of digestible matter per acre, since the cow used in the experiment with green grass, already reported, was a better milker than those used in this experiment. As has been noted in another connection, such a comparison may be somewhat unfair to the pasture grass on account of the larger proportion of protein which the latter contains, but we give it for what it is worth. The total product of one acre of pasture for the season up to Sept. 29, was found to be 710 pounds of digestible matter. The cows used in this experiment required on the average of the whole experiment 0.7657 pounds digestible matter to make one pound of milk and 18.9 pounds digestible matter to make one pound of butter.* At this rate the 710 pounds of digestible matter furnished by the acre of pasture would produce 928 pounds milk and 38 pounds of butter, so that the comparison with soiling crops stands as follows:

Product per Acre.

	Milk.	*Butter.*
Soiling,	3,416	139
Pasturage,	927	38
Difference,	2,489	101

It is not proposed here to enter into any consideration of the financial side of the question as between pasturage and soiling. Some preliminary estimates seem to show a decided advantage in favor of pasturage, but we have made no exact experiments, and until we are able to do so we prefer to keep our conjectures to ourselves.

In conclusion, it cannot be too emphatically stated that the figures and comparisons of the foregoing papers are only tentative and preliminary. No one spot of grass land can represent all pastures. No one season can represent all the varieties of climate. No single crop of soiling can show all the possibilities there are in the system.

We are well aware that the above experiments are deficient in many respects, and it has been our endeavor to bring forward somewhat prominently these deficiencies, in order to guard the reader against rash conclusions from our results. We hope to be able to continue experiments in this direction, and to reach in time more definite results.

* Assuming total weight of fat in the milk to represent the butter product.

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GENERAL FERTILIZER EXPERIMENTS.

BY WM. H. CALDWELL.

A system of field experiments for the purpose of comparing the effects of various commercial and domestic fertilizers upon the staple crops was begun in 1881. Four tiers of thirty-six $\frac{1}{8}$-acre plots were laid out for the experiment. A four years' rotation of crops consisting of corn, oats, wheat and grass was adopted. The following shows the occupation of the land since 1881, previous to that it having been used for miscellaneous field experiments.

	1881.	1882.	1883	1884.	1885.	1886.	1887	1888.
Tier 1,	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.	Grass.	Corn.
" 2,	Corn.	Oats	Wheat.	Grass.	Corn.	Oats.	Wheat.	Grass.
" 3	.....	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.	Wheat.
" 4,	.....	.....	Corn.	Oats.	Wheat.	Grass.	Corn.	Oats.

The design of these experiments has been to throw light especially upon the following points:

The comparative effect of the single valuable ingredients of commercial fertilizers.

The effect of complete, as compared with incomplete, fertilizers.

The comparative effect of different forms of nitrogen.

The necessary artificial supply of nitrogen.

The comparative effect of commercial fertilizers and yard manure.

The effect of lime, ground limestone and plaster.

The permanency of effect of the different fertilizers.

The effect of the various fertilizers upon the comparative growth of the different crops.

The effect of the various fertilizers upon the relation of grain to straw.

The method of conducting these experiments has been fully described several times, and full details in regard to it may be obtained by reference to the College reports for 1882 and 1883, the latter of which was printed in the Agriculture of Pennsylvania for that year, and also to College bulletins Nos. 1, 2, 8, 9, 11 and 14; compare also the report of the Station for 1887.

The following materials were used as the sources of the several ingredients to be compared: *soluble phosphoric acid*, dissolved bone-black: *less soluble phosphoric acid*, ground bone; *potash*, muriate of potash; *nitrogen*, dried blood, sulphate of ammonia and nitrate of soda; *lime*, burnt lime, ground limestone and plaster.

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The preparation of the soil, the manner and time of seeding, cultivation and harvesting were, as nearly as possible, the same on all plots.

The fertilizers, with the exception of lime, were applied to the corn and wheat, oats and grass receiving none. The lime was applied to the corn crop only.

All the fertilizers except yard manure were sown upon the well pulverized soil, and then harrowed in. The yard manure was spread and plowed in, as in ordinary farm practice.

The commercial fertilizers were used in such quantities that wherever either of the mineral ingredients, potash and phosphoric acid, was applied, the same quantity per acre was given; forty-eight and one hundred pounds respectively. Different groups of plots received nitrogen from each of the three different sources of nitrogen in quantities of twenty-four, forty-eight and seventy-two pounds per acre. It has unfortunately been impossible until this season to subject the different fertilizers used to analysis, and these estimates are based upon the average analyses of the materials employed, care always being exercised to procure a good grade. This season the fertilizers were analyzed and the exact number of pounds required to furnish the amount of nitrogen, phosphoric acid and potash used on the plot were applied. The yard manure was the mixed product of the dairy and horse stables, and made from hay, cornfodder, soiling crops, corn, oats and bran.

The soil of the farm is a limestone clay loam through which fragments of flint are thickly scattered. The soil is naturally well drained, and contains a good supply of organic matter. The depth of the surface soil is about eight inches, but that of the quite compact subsoil is very variable.

The difficulties encountered in endeavoring to obtain exact equality of all conditions affecting the growth of the crop upon each plot, were spoken of at length in the last annual report of this Station.* It is sufficient to note here that it would not be wise to deduce general conclusions from results of one season or from those of one rotation. Reliance can only be placed on conclusions drawn from repeated tests This report, then, is made as one of progress leaving the drawing of conclusions until some future time.

Results for 1888. Single Plots.

The season of 1888 was more moist and somewhat colder than the average, yet good grain crops were secured.

In the table given below will be found the yield for the season of all the plots singly in each tier. The results per acre are expressed in tons and bushels. It should be remembered that these are computed and not actual yields. The yield of each plot in pounds being multiplied by eight (the plot being one eighth of an acre) and the result obtained reduced to bushels and tons.

* Report Penn. State College Ag'l. Exp. Station for 1887, p. 26 and 27.

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Yield of Single Plots, 1888.

	Plot	Kind of Fertilizer.	Quality of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Quantities of Valuable Ingredients—Pounds per Acre.			Tier I. Corn.			Tier IV. Oats.			Tier III. Wheat.			Tier II. Grass.
					Nitrogen.	Phosphoric acid.	Potash.	Ears. Bush.	Fodder. Tons.	No. of Stalks per acre.	Grain. Bush.	Straw Tons.	Lbs. per bush.	Grain. Bush.	Straw. Tons.	Lbs. per bush	Hay Tons.
	1	Nothing.						40 09	1.24	9 408	58.13	0 85	31 00	17 1	0 61	63 00	1.56
Valuable ingredients, singly.	2	Dried blood,	190	190	24			49.33	1 45	10 024	49 73	0 96	32 50	22 17	0 82	63.50	1.34
	3	Dissolved bone-black,	292	292		48		51 87	1 73	9.536	46.00	0 88	33 50	15 23	0 46	60 25	1 72
	4	Muriate of potash,	194	194			100	53 33	2 00	10 000	48 93	0 89	33 00	16.20	0.51	64 25	1 44
Valuable ingredients, two by two	5	Dried blood, 190 / Dissolved bone-black, 292		482	24	48		59 73	1.68	9 472	52 00	0 90	33 50	22.90	0 91	61 25	1.60
	6	Dried blood, 190 / Muriate of potash, 194		384	24		100	40 53	1 70	9 936	52 93	0 81	33 50	23 70	0 87	61 25	1 56
	7	Dissolved bone-black, 292 / Muriate of potash, 194		486		48	100	65 07	2 29	9 672	52 40	0 99	34 0	17 00	0 57	61 75	2 12
	8	Nothing.						64 00	1 82	9,944	47 47	0 77	32 00	22 47	0 88	63 25	2 04
Complete fertilizers, with nitrogen in different proportions. Nitrogen furnished bydried blood.	9	Dissolved bone-black, 292 / Muriate of potash, 194 / Dried blood, 190		676	24	48	100	59 73	1 81	9,672	52.00	0 81	33 00	24 83	0 93	62 75	2 26
	10	Dissolved bone-black, 292 / Muriate of potash, 194 / Dried blood, 380		866	48	48	100	89 20	2 39	9,784	59.47	0 81	34 00	29 97	1 34	63 25	1 84
	11	Dissolved bone-black, 292 / Muriate of potash, 194 / Dried blood, 570		1 056	72	48	100	62 40	2 51	9,672	57 20	0 92	33 50	33 17	1 45	60.75	1 72
	*12	Ground bone, 232 / Muriate of potash, 194 / Dried blood, 190		616	30	48	100	66 13	2 50	10,006	53 47	0 84	32 50	25 27	0 90	61 25	2 01
	13	Plaster,	320	320				52 27	1 48	10 256	44 00	0 88	31.00	18 23	0 53	63 00	2 02
	14	Nothing,						56 53	1 74	9.976	40 40	0 77	32 50	20.60	0 66	62 25	1.82
	15	Dissolved bone black, 292 / Muriate of potash, 194		486		48	100	73 60	2 68	11 160	45 07	0 64	32.00	18 53	0.60	62 25	2 09
Commercial fertilizers and yard manure compared.	16	Yard manure,	12,000	12.000	?	?	?	68 27	2 42	10,704	50.93	0 87	31.00	26 96	1 07	61 75	1 86
	17	Dissolved bone black, 292 / Muriate of potash, 194 / Dried blood, 190		676	24	48	100	57 07	2 88	10,376	44 07	0.62	31 25	19 40	0 72	61 75	1 66
	18	Yard manure,	16 000	16 000	?	?	?	61 33	1 82	10,352	47 87	0.96	31.50	26 87	1 06	63 00	1 64
	19	Dissolved bone-black, 292 / Muriate of potash, 194 / Dried blood, 380		866	48	48	100	66 66	3 00	10,728	47 47	0 71	34 00	25 37	1 12	61 75	2 00
	20	Yard manure,	28,000	28,000	?	?	?	73 33	2 88	10,624	47 73	0 82	32 00	25 53	0 95	63 75	1 48

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Commercial fertilizers and yard manure compared.	21	Dissolved bone-black,	292																
		Muriate of potash,	194	1 066	72	48	100	73 60	2 84	10 920	46 93	0.85	35 00	29 47	1 82	60 75	1 53		
		Dried blood,	270																
	22	Yard manure,	12 100	16.000	?	?	?	7: 80	2 46	11 072	51 73	1 08	32 00	23 13	1 17	61 25	1 64		
		Lime,	4 000																
	†23	Lime,	4 000	4 000	?	. . . .	. . . .	53.87	1 56	10, 184	42 93	0 95	30 50	25.27	0 70	62.75	1 05		
	24	Nothing,				. . . .	. . . .	46.27	1 32	9.912	43 47	0 75	24 00	18.47	0 62	64 25	1.16		
Complete fertilizers with nitrogen in different proportions. Nitrogen furnished by nitrate of soda.	25	Dissolved bone-black,	292																
		Muriate of potash,	194	498	. . .	48	100	78 13	2 96	0,488	45 89	0.81	36.00	21 53	0 85	63 25	1.73		
		Dissolved bone-black,	292																
	26	Muriate of potash,	194	670	24	48	100	73.07	2.84	11,160	44.00	0.74	34 00	23 27	0 66	62 75	1 69		
		Nitrate of soda,	184																
		Dissolved bone-black,	292																
	27	Muriate of potash,	194	854	48	48	100	64 53	2 94	10,656	53 67	0 90	34 68	26 00	1 05	63 25	1 68		
		Nitrate of soda,	268																
		Dissolved bone-black,	292																
	28	Muriate of potash,	194	1 066	72	48	100	61 87	2 26	10, 224	56.67	0.86	34 00	23 93	1 53	63 75	1 44		
		Nitrate of soda,	552																
Complete fertilizer, with nitrogen in different proportions. Nitrogen furnished by sulphate of ammonia.	29	Dissolved bone-black,	292																
		Muriate of potash,	194	496	. .	48	100	65.33	2 02	10,416	48 00	0 84	36.00	17 33	0 82	62.75	1 80		
		Dissolved bone-black,	292																
	30	Muriate of potash,	194	610	24	48	100	66.40	2.56	10,224	55 47	0 77	33 00	25 60	1 11	60 50	1 54		
		Sulphate of ammonia,	124																
		Dissolved bone-black,	292																
	31	Muriate of potash,	194	734	46	48	100	75 20	2.96	10,906	56 53	0 97	34 50	25.27	1.47	60.25	1 43		
		Sulphate of ammonia,	243																
		Dissolved bone-black,	292																
	32	Muriate of potash,	194	858	72	48	100	72.00	2 76	10,800	50.53	1 04	35.00	28 33	1.69	62 25	1.64		
		Sulphate of ammonia,	272																
	33	Plaster.	320	320	. . .	. . . .	. . .	48 00	1.64	9.888	46 13	1 14	34 00	22.27	0 69	61 75	1 23		
	34	Ground limestone,	4 000	4,000	. .	. . . .	. . .	56 00	1 46	9.240	45 87	1.13	34 50	22 93	0 67	63.75	0 98		
		Ground bone,	223																
	‡35	Muriate of potash,	194	616	30	48	100	73 60	2 70	10,080	44 00	1.10	34 00	24 73	2.00	62.75	1.24		
		Dried blood,	190																
	36	Nothing,		. .		. . . .	. . . .	58 67	1 74	9.712	39 73	0 76	22 00	22.07	0.74	59 75	0 46		

*Prior to 1884-5, received the same as No. 9. †Applied only to corn. ‡Prior to 1884-5, received the same as No. 7.

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In order to facilitate the comparison of results in the following tables the yields are expressed in pounds and those plots receiving similar treatment are grouped together and the average yield given.

CORN.

With the exception of the autumn months, the season of 1888 was favorable for corn. The fall rains greatly hindered the successful curing of the stover. The table given shows the yield of corn per acre for this season's crop, and also the average of previous crops and the gain over unfertilized plots. By comparison it will be seen that the yield for 1888 was above an average one.

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Average Yield of Plots receiving the same Fertilizer—Corn, 1888.

No.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.						Gain over Unfertilized Plots.					
					Average of previous crops — 1881-1887.			Tier I - 1888.				Average of previous crops — 1881-1887.			Tier I - 1888.		
					Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop.	No. of Stalks per acre.	Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop.
		Pounds.	*Pounds.*														
1	Nothing,			5	3 392	2,346	5,738	4,012	3 144	7,156	9 790	..	..	..	..	..	..
2	Dried blood,	190	190	1	3 439	2,357	5,796	3 700	2 900	6 600	10 024	47	11	58	−312	−244	−556
3	Dissolved bone-black,	292	292	1	3,316	2,427	5 743	4 080	3 560	7 640	9,536	−76	81	5	68	416	484
4	Muriate of potash,	194	194	1	3,444	2,603	6,047	4 000	4.000	8 000	10,000	52	257	309	−12	856	844
5	Dried blood, 190 Dissolved bone-black, 292	482		1	3,612	2,531	6 143	4 480	3 360	7 840	9,472	220	185	405	468	216	684
6	Dried blood, 190 Muriate of potash, 194	384		1	3,462	2 697	6,159	3,040	3,400	6 440	9 936	70	351	421	− 972	256	− 716
7	Dissolved bone-black, 292 Muriate of potash, 194	486		*5	3,618	2,719	6 337	5,290	5 225	10,515	10,434	226	373	599	1,278	2,081	3 359
8	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 190	676		†3	3,457	2,722	6,179	4,380	4,690	9,070	10.124	65	376	441	368	1,546	1 914
9	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 380	866		2	3 610	2,805	6,415	4 720	5 390	10,110	10 256	218	459	677	708	2,246	2,954
10	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 570	1,056		2	3 616	2,823	6,439	5,100	5 350	10,450	10,296	224	477	701	1,088	2 206	3,294
11	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 184	670		1	3,737	2,876	6 613	5,480	5,760	11,240	11,160	345	530	875	1,468	2,616	4 084
12	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 368	854		1	3,671	2 883	6,554	4,840	5 680	10,520	10,656	279	537	816	528	2 536	3 364
13	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 552	1,038		1	3,629	2 797	6 426	4,640	4 720	9,360	10 824	237	451	688	628	1 576	2,204
14	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 124	610		1	3 636	2,916	6,551	4.960	5,180	10,140	10,224	243	570	823	968	2 016	2,984
15	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 248	734		1	3,772	3,004	6,776	5,640	5,960	11,600	10,808	330	658	1 038	1,628	2 816	4,444

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Average Yield of Plots receiving the same Fertilizer—Corn, 1888—Continued.

No.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.						Gain over Unfertilized Plots.					
					Average of previous crops—1881–1887.			Tier I—1888.				Average of previous crops—1881–1887.			Tier I—1888.		
					Ears.	Fodder.	Total crop.	Ears.	Fodder.	Total crop.	No. of Stalks per acre.	Ears	Fodder.	Total crop.	Ears.	Fodder.	Total crop.
		Pounds.	*Pounds.*														
16	Dissolved bone-black,	292	858	1	3,613	2,943	6 556	5 400	5 520	10 920	10 800	221	597	818	1,388	2,376	3 764
	Muriate of potash,	194															
	Sulphate of ammonia,	372															
17	Yard manure,	12,000	12.000	1	3,747	2 413	6,180	5.120	4 840	9.980	10 704	375	67	442	1,108	1 696	2,804
18	Yard manure,	16 000	16 000	1	4.042	2 426	6 468	4 600	3 640	8 240	10,352	650	80	730	568	496	1 694
19	Yard manure,	20 000	20,000	1	3,636	2,366	6,002	5,500	5, 60	11,260	10 624	244	20	264	1,488	2,616	4,104
20	Yard manure,	12 000	16,000	1	3 619	2,396	6,005	5 760	4,920	10.680	11 072	227	40	267	1 748	1,776	3 524
	Lime,	4,000															
21	Lime,	4 000	4,000	1	3,143	1,971	5,114	4.040	3 160	7,200	10, 184	−249	−375	− 624	28	16	44
22	G ound limestone,	4,000	4 000	1	3,196	2.198	5 394	4,200	2.920	7 120	9 240	−196	−148	−344	188	−244	- 56
23	Plaster,	320	320	12	3,456	2,334	5,790	3,760	3,120	6 880	10 072	64	−12	52	−252	− 24	-- 276
24	Ground bone,	232	616	§2	3,955	2,399	6, 354	5,240	5,200	10 440	10,044	563	53	616	1.228	2 056	3,284
	Muri te of potash,	194															
	Dried blood,	190															
	Average of plots receiving complete fertilizers containing—																
	Dried blood,			17	3.553	2.773	6 326	4 730	5.143	9,873	10 285	161	427	588	7:8	1.999	2 717
	Nitrate of soda,			3	3 679	2,900	6 579	4 967	5 397	10,374	10, 880	287	554	1, 841	975	2.243	3 219
	Sulphate of ammonia,			3	3,673	2 954	6 627	5 340	5.547	10 887	10,612	281	608	889	1 223	2,403	3 731
	Nitrogen, 24 lbs.,			¶5	3.570	2.803	6 373	4,705	5,075	9 880	10. 408	178	457	635	793	1 931	2 724
	Nitrogen, 48 lbs.,			4	3 684	2 897	6.581	4 980	5 605	10.585	10 494	292	551	843	968	2,461	3 429
	Nitrogen, 72 lbs.,			4	3 618	2 854	6.472	5 060	5 235	10 295	10.554	226	508	734	1,048	2 091	3,139
	Yard manure,			4	3,815	2,404	6,219	5,245	4 790	10,035	10,680	423	58	481	1,238	1,646	2,879

* 4 after 1884–1885. † 2 after 1884–1885 § First applied to wheat, 1884–1885. ‖ 6 after 1884–1885. ¶ 8 after 1884–1885

‡ By error, plot 33 received application of fertilizer for plot 35 at corn planting, 1885.

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The figures given last year showed that the yield of ears was proportionally large while those given below for this season's crop show the reverse.

Proportion of Ears to Fodder.

KIND OF FERTILIZER.	Average for 1881-1887.	Crop of 1888.
Nothing.		
Dissolved bone black,	1 : .691	1 : .783
Muriate of potash,	1 : .751	1 : .986
Complete fertilizers containing:		
Dried blood,	1 : .780	1 : 1.087
Nitrate of soda,	1 : .706	1 : 1.080
Sulphate of ammonia,	1 : .804	1 : 1.038
Nitrogen, 24 lbs.,	1 : .784	1 : 1.054
Nitrogen, 48 "	1 : .786	1 : 1.125
Nitrogen, 72 "	1 : .706	1 : 1.034
Yard manure,	1 : .664	1 : .913
Lime,	1 : .607	1 : .782

Grain equals 1.

It was noted from last season's work, and from the results of previous seasons, that the proportion of ears was greatest on plots receiving yard manure than on those receiving any other complete fertilizer. The proportion of ears is also exceptionally large where lime has been applied.

OATS.

As the oats received no fertilizer other than the residuum from the previous year's crop of corn, it is necessary to compare the combined crops of corn and oats. The following table shows the yield of corn for 1887, oats for 1888, the weight per bushel for 1888, the combined crops and the comparison of same with results of previous years.

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Average Yield of Plots Receiving Same Fertilizer. Corn and Oats, 1887—1888.

No.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizers per acre.	Number of plots.	Yield Per Acre.													
					Average of previous years.							Tier IV.						
					Corn, 1881-1886.			Oats, 1882-1887.			Combined crops, 1881-1887.	Corn, 1887.			Oats, 1888.				Combined crops 1887—1888.
					Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.		Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.	Wt. per bush.	
1.	Nothing,	....	....	5	3,806	2,396	5,702	1,310	1,796	3,106	8,808	3,912	2,048	5,960	1,375	1,561	2,936	32.3	8,896
2.	Dried blood,	190	190	1	3,330	2,386	5,716	1,314	1,805	3,119	8,835	4,080	2,180	6,260	1,492	1,928	3,420	32.5	9,680
3.	Dissolved bone-black,	292	292	1	3,286	2,508	5,744	1,372	1,760	3,132	8,876	3,800	1,940	5,740	1,380	1,760	3,140	33.5	8,880
4.	Muriate of potash,	194	194	1	3,872	2,660	6,032	1,206	1,821	3,027	9,059	3,880	2,260	6,140	1,464	1,776	3,240	33.0	9,380
5.	Dried blood, 190 Dissolved bone-black, 292		482	1	3,591	2,643	6,234	1,280	1,877	3,157	9,391	3,740	1,860	5,600	1,560	1,800	3,360	33.5	8,960
6.	Dried blood, 190 Muriate of potash, 194		384	1	3,405	2,767	6,172	1,355	1,970	3,325	9,497	3,800	2,280	6,080	1,588	1,612	3,200	33.5	9,280
7.	Dissolved bone black, 292 Muriate of potash, 194		486	*5	3,555	2,775	6,330	1,570	1,929	3,499	9,829	3,995	2,380	6,375	1,485	1,595	3,080	34.4	9,400
8.	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 190		676	†3	3,398	2,824	6,217	1,492	1,985	3,477	9,694	3,840	2,110	5,950	1,441	1,429	2,870	32.1	8,820
9.	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 380		866	2	3,525	2,878	6,403	1,545	2,130	3,675	10,078	4,120	2,370	6,490	1,601	1,516	3,120	34.0	9,610
10.	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood 570		1,056	2	3,576	2,903	6,479	1,534	2,018	3,602	10,081	3,860	2,340	6,200	1,562	1,768	3,330	34.3	9,530
11.	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 184		670	1	3,633	2,892	6,525	1,539	1,913	3,452	9,977	4,360	2,780	7,140	1,320	1,480	2,800	34.0	9,940
12.	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 368		854	1	3,509	2,820	6,329	1,604	1,984	3,588	9,917	4,640	3,260	7,900	1,616	1,604	3,220	34.0	11,120
13.	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 552		1,038	1	3,494	2,733	6,227	1,540	2,132	3,672	9,899	4,440	3,180	7,620	1,760	1,720	3,480	34.0	11,100
14.	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 124		610	1	3,451	2,892	6,343	1,577	2,136	3,713	10,056	4,740	3,060	7,800	1,664	1,536	3,200	35.0	11,000
15.	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 248		734	1	3,574	2,921	6,495	1,608	2,261	3,869	10,364	4,960	3,500	8,460	1,696	1,944	3,640	34.5	12,100

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16.	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 372	858	1	3,398	2,873	6,271	1,614	2,160	3,774	10,045	4,900	3,860	8,260	1,516	2,084	3,600	35.0	11,860
17.	Yard manure,	12,000	12,000	1	3,785	2,523	6,308	1,457	2,131	3,588	9,896	3,660	1,760	5,420	1,528	1,752	3,280	31.0	8,700
18.	Yard manure,	16,000	16,000	1	4,040	2,467	6,507	1,468	1,864	3,332	9,839	4,020	2,180	6,200	1,436	1,924	3,360	3 .5	9,560
19.	Yard manure,	20,000	20,000	1	3,586	2,384	5,970	1,474	1,917	3,391	9,361	3,940	2,260	6,200	1,432	1,648	3,080	32.0	9,280
20.	Yard manure, 12,000 Lime, 4,000	16,000	1	3,533	2,420	5,953	1,481	2,312	3,793	9,746	4,120	2,180	6,300	1,552	2,068	3,620	32.0	9,920
21.	Lime,	4,000	4,000	1	3,060	2,013	5,073	1,317	1,910	3,227	8,300	3,640	1,720	5,360	1,288	1,892	3,180	30.5	8,510
22.	Ground limestone,	4,000	4,000	1	3,112	2,221	5,333	1,380	2,596	3,776	9,109	3,760	2,060	5,820	1,376	2,264	3,640	34.5	9,460
23.	Plaster,	320	320	†2	3,348	2,390	5,738	1,394	2,262	3,656	9,394	4,100	2,000	6,100	1,352	2,018	3,370	32.5	9,470
24.	Ground bone, 252 Muriate of potash, 194 Dried blood, 190	636	§2	3,643	2,183	5,826	1,626	2,230	3,856	9,682	4,580	2,820	7,400	1,462	1,988	3,400	33.8	10,800
	Average of plots receiving complete fertilizers, containing—		‖7	3,489	2.856	6,345	1,527	2,016	3,573	9,918	3,940	2,273	6,213	1,536	1,571	3,107	33.5	9,320
	Dried blood,		3	3,545	2,815	6,360	1,560	2,010	3,570	9,930	4.480	3 407	7,887	1,565	1,601	3,166	34.0	11,053
	Nitrate of soda,		3	3,474	2,895	6,369	1,571	2,176	3,747	10,116	4,567	3,307	8,174	1,620	1,855	3,480	31.8	11,654
	Sulphate of ammonia,		¶5	3,446	2,829	6,275	1,515	1,990	3,505	9,780	4,313	2,620	6,933	1,467	1,468	2,935	33.3	9,898
	Nitrogen, 24 pounds,		4	3,536	2,873	6,409	1,574	2,120	3,694	10,103	4,573	3,043	7,616	1,630	1,645	3,275	34 1	10,891
	Nitrogen, 48 pounds,		4	3,488	2,836	6,324	1,572	2,096	3.668	9,992	4,100	2.900	7,320	1,600	1,835	3,435	34.4	10,795
	Nitrogen, 72 pounds,		4	3,806	2,459	6,265	1,467	2,063	3,500	9,765	3,873	2,067	5,940	1,487	1,848	3,335	31.6	9,275
	Yard manure,																	

*4 after 1884-1885. † 2 after 1884-1885. First applied to wheat, 1884-1885.

‖6 after 1884-1885. ¶ 8 after 1884-1885. ‡ By error plot 33 received application of fertilizer, for plot 35, at corn planting, 1885.

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It will be seen from the table that the yield was not quite up to that of previous years though somewhat better than that of last season. The oats were drilled on April 18, 1888, one bushel and three pecks of seed per acre being used. June 26th, observations on the relative difference in the rate of heading out of the crop on the different plots were taken. On most of the plots the oats were well headed: Nos. 1 (nothing), 3 (dissolved bone black), 13 (plaster), 14 (nothing) and 22 (yard manure and lime), had only a few heads on each. Plot No. 23 (lime) was the only one where no heads were noticed. July 19th the crop on the plots was well colored save on those receiving yard manure. Where that was applied it had not ripened as much as where complete commercial fertilizers were used, and where it was applied the heaviest the oats seemed the greenest. On plots to which lime and ground limestone were applied the oats were also quite green. During the latter part of July the crop on the plots to which yard manure was applied had ripened much faster than on those which had received the lime and ground limestone.

The next table shows the gain in yield of the plots receiving some fertilizing ingredient over that from the unfertilized plots.

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Average Gains Over Unfertilized Plots. Corn and Oats 1887–'88.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Gain Over Unfertilized Plots.													
					Average of previous years.							Tier IV.						
					Corn, 1881–1886.			Oats, 1882–1887.			Combined crops, 1881–1887.	Corn, 1887.			Oats, 1888.				Combined crops, 1887–1888.
					Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.		Ears.	Fodder.	Total crop	Grain.	Straw.	Total crop.	Wgt. per bushel.	
1	Nothing,	.....	.....	5	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
2	Dried blood,		190	1	24	−10	14	4	9	13	27	168	132	300	117	367	484	0.2	784
3	Dissolved bone-black,	292	292	1	−70	112	42	62	−36	26	68	−112	−108	−220	5	199	204	1 2	16
4	Muriate of potash,	194	194	1	66	264	330	−104	25	−79	251	−32	212	180	89	215	304	0.7	484
5	Dried blood, / Dissolved bone-black,	190 / 292	482	1	235	247	532	−30	81	51	583	−172	−183	−360	185	239	424	1 2	64
6	Dried blood, / Muriate of potash,	190 / 194	384	1	99	371	470	45	174	219	689	−112	232	120	213	51	264	1 2	384
7	Dissolved bone-black, / Muriate of potash,	292 / 194	486	*5	249	379	628	260	133	393	1,021	83	332	415	60	34	94	2.1	509
8	Dissolved bone-black, / Muriate of potash, / Dried blood,	292 / 194 / 190	676	†3	87	428	515	182	189	371	886	−72	62	−10	66	−132	−66	−0 2	−76
9	Dissolved bone-black, / Muriate of potash, / Dried blood,	292 / 194 / 380	866	2	219	482	701	235	334	569	1,270	208	322	530	229	−45	184	1 7	714
10	Dissolved bone-black, / Muriate of potash, / Dried blood,	292 / 194 / 570	1,056	2	270	507	777	244	252	496	1,273	−52	292	240	167	207	394	2.0	634
11	Dissolved bone-black, / Muriate of potash, / Nitrate of soda,	292 / 194 / 184	670	1	327	596	823	229	117	346	1,169	443	732	1,180	−55	−81	−136	1.7	1,044
12	Dissolved bone-black, / Muriate of potash, / Nitrate of soda,	292 / 194 / 368	854	1	203	424	627	294	188	482	1,109	728	1 212	1,940	241	43	284	1 7	2 224
13	Dissolved bone-black, / Muriate of potash, / Nitrate of soda,	292 / 194 / 552	1,038	1	188	337	525	230	336	566	1,091	528	1 132	1,660	385	159	544	1.7	2,204
14	Dissolved bone-black, / Muriate of potash, / Sulphate of ammonia,	292 / 194 / 124	610	1	145	496	641	267	340	607	1,248	828	1,012	1 840	289	−25	264	2.7	2,104
15	Dissolved bone-black, / Muriate of potash, / Sulphate of ammonia,	292 / 194 / 248	734	1	268	525	793	298	465	763	1,556	1,043	1,452	2 500	321	383	704	2 2	3,204

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Average Gains Over Unfertilized Plots. Corn and Oats, 1887–'88—Continued.

Number.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Gain Over Unfertilized Plots.													
					Average of previous years.							Tier IV.						
					Corn, 1881-1886.			Oats, 1882-1887.			Combined crops, 1881-1887.	Corn, 1887.			Oats, 1888.				Combined crops, 1887-1888.
					Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.		Ears.	Fodder.	Total crop.	Grain.	Straw.	Total crop.	Wgt per bushel.	
16	Dissolved bone-black, / Muriate of potash, / Sulphate of ammonia,	292 / 194 / 372	858	1	92	477	569	304	364	668	1,237	988	1,312	2 300	141	523	664	2 7	2,964
17	Yard manure,	12.000	12.000	1	479	127	606	147	335	482	1,088	−252	−288	−540	153	191	344	−1 3	−196
18	Yard manure,	16 000	16 000	1	734	71	805	158	68	226	1,031	108	132	240	61	363	424	−0 8	664
19	Yard manure,	20 000	20,000	1	280	−12	268	164	121	285	553	28	212	240	57	87	144	−0.3	384
20	Yard manure, / Lime,	12 000 / 4 000	16,000	1	227	24	251	171	516	687	938	208	1 32	340	177	507	684	−0 3	1,024
21	Lime,	4 000	4.000	1	−246	−383	−629	7	114	121	−508	−272	−328	−600	−87	331	244	−1 8	−356
22	Ground limestone,	4 000	4 000	1	−194	−175	−369	70	600	670	301	−152	12	−140	1	703	704	2 2	664
23	Plaster,	320	320	‡2	42	−6	36	84	466	550	586	188	−48	140	−23	457	434	0 2	574
24	Ground bone, / Muriate of potash, / Dried blood,	232 / 194 / 190	616	§2	337	−213	124	316	434	750	874	668	772	1,440	87	377	464	1 5	1,904
	Average yield of plots receiving complete fertilizers containing—																		
	Dried blood,			¶7	183	460	643	217	250	467	1.110	28	225	253	161	10	171	1.2	424
	Nitrate of soda,			3	239	419	658	250	214	464	1 122	568	1,359	1 927	190	40	230	1 7	2 157
	Sulphate of ammonia,			3	168	499	667	281	280	641	1,308	955	1,259	2 214	280	294	544	2.5	2 758
	24 pounds of nitrogen,			¶5	140	433	573	205	194	399	972	401	602	1 003	92	−93	−1	1 0	1 002
	48 pounds of nitrogen,			4	230	477	707	264	324	588	1.295	631	995	1,656	255	84	339	1 8	1 995
	72 pounds of nitrogen,			4	182	440	622	232	300	562	1,184	488	912	1,400	225	274	499	2 1	1,899
	Yard manure,			4	500	63	563	157	237	394	957	−39	19	−20	112	287	399	−0 7	379

*4 after 1884-1885. †2 after 1884-1885. §First applied to wheat, 1884-1885. ‖6 after 1884-1885. ¶8 after 1884-1885.

‡ By error, plot 23 received application of fertilizer for plot 35 at corn planting, 1885.

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WHEAT AND GRASS.

Owing to the severe attack of the fly and winter killing, the wheat crop of 1887 was a failure. It would, therefore, be unwise to include it in the average, and consequently in the following table there is nothing to combine with the grass crop of 1888. This season's grass crop is included in this table instead of, as formerly, in a separate one; there is also given a table showing the gain in yield over unfertilized plots.

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Average Yields of Plots Receiving Same Fertilizers—Wheat and Grass, 1888.

No.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quantity of fertilizer per acre.	Number of plots.	Yield per Acre.									
					Average of previous crops, 1882-1887.					Tier III.				Tier II.
					Wheat, 1882-1887.			Grass, 1883 1888. Hay.	Combined crops, 1883-1887.	Wheat, 1888.				Grass, 1888. Hay.
					Grain.	Straw.	Total crop.			Grain.	Straw.	Total crop.	Wgt. per bushel.	
		Pounds.												
1	Nothing,			5	823	1,220	2 043	3 403	5.446	1,209	1 379	2 538	62.5	2 816
2	Dried blood,	190	190	1	762	1.310	2 072	3 128	5.200	1,330	1,630	2.960	63 5	2 760
3	Dissolved bone-black,	292	292	1	936	1.471	2 407	3 120	5.527	914	926	1 840	60 3	3.440
4	Muriate of potash,	194	194	1	777	1,190	1,967	3,103	5,070	972	1,028	2,000	64,3	2,880
5	Dried blood, 190 Dissolved bone-black, 292		482	1	1,072	1,641	2,713	3 584	6,297	1,374	1,826	3 200	61.3	3,320
6	Dried blood, 190 Muriate of potash, 194		384	1	805	1,288	2,093	2,911	5,004	1,422	1,738	3 160	61.3	3 120
7	Dissolved bone-black, 292 Muriate of potash, 194		486	*5	1,169	1,701	2,870	3,735	6,605	1.116	1,020	2,136	62 6	3,880
8	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 190		676	13	1,147	1,996	3,143	3,728	6,871	1,329	1 652	2,980	62.3	3,920
9	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 380		866	2	1,297	2,246	3,543	3,857	7,400	1,660	2,460	4,120	62.3	3,840
10	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 570		1,056	2	1,402	2,177	3,579	3 893	7,472	1,879	2,761	4 640	60.8	3,250
11	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 184		670	1	1,428	2,321	3,749	3,844	7 593	1,396	1,824	2,720	62 8	3,200
12	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 368		854	1	1,461	2,459	3 920	3,784	7,704	1,500	2,100	3 600	63 3	3,320
13	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 552		1,038	1	1,473	1,940	3,413	3,772	7,185	2 036	3 164	5,200	63 8	2,880
14	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 124		610	1	1,410	2,194	3 604	4 347	7 951	1,536	2,224	3,760	60.5	3,080
15	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 248		734	1	1,674	2,760	4 434	4,332	8,766	1,696	2,944	4,640	60 8	2,960

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16	Dissolved bone-black, 202 Muriate of potash, 194 Sulphate of ammonia, 372	858	1	1,694	2 819	4,513	4,032	8,545	1,700	3,380	5,080	62 8	2,030
17	Yard manure, 12 000	12 000		1 249	1 962	3.211	3 595	6 806	1 614	2.146	3 760	61 5	3.720
18	Yard manure, 16.000	16.000	1	1.208	2,009	3 217	3 838	7 105	1 612	2 116	3 728	63 0	3 240
19	Yard manure, 20 000	20 000	1	1,252	2,087	3,339	3,504	6.343	1,532	1 908	3 440	63.8	2,930
20	Yard manure, 12.000 Lime, 4 000	16 000	1	1,235	1.953	3,138	3 600	6 783	1,383	2.832	3,720	6 .3	3.280
21	Lime, 4 000	4 000	1	810	1 411	2.301	3 367	5 668	1 516	1 404	2 920	62 8	2 100
22	Ground limestone, 4 000	4 000	1	848	1.318	2 164	3 756	5 920	1.376	1 744	3 120	63 8	1 920
23	Plaster, 320	320	‡2	802	1,276	2 078	3.256	5,334	1,215	1,225	2,440	62.4	3,300
24	Ground bone, 233 Muriate of potash, 194 Dried blood, 190	616	§2	593	1,040	1,633	5,054	6 687	1,500	1,900	3,400	62 0	3,250
	Average yield of plots receiving complete fertilizers containing –												
	Dried blood,		¶7	1 293	2.118	3 411	3 818	7 229	1 622	2 291	3.913	61 8	3.670
	Nitrate of soda,		3	1 456	2 240	3 696	3 800	7 436	1.644	2 196	3 840	63 3	3 132
	Sulphate of ammonia,		3	1.553	2 591	4 144	4 224	8 468	1.644	2 849	4 493	61 2	2 707
	Nitrogen, 24 pounds per acre,		¶5	1.297	2 101	3 398	3 902	7 300	1 397	1 713	3 110	62 0	3 530
	Nitrogen, 48 pounds per acre,		4	1 432	2 628	4 060	3 933	7 998	1.629	2 491	4 120	62 0	3.490
	Nitrogen, 72 pounds per acre,		4	1 493	2 417	3 910	3 997	7 807	1 874	3 018	4 890	62 0	2 765
	Yard manure,		4	1,176	2,019	3 195	4,262	7,457	1,536	2,126	3,662	62 4	3,310

* 4 after 1884-1885. † 2 after 1884 1885. ‡ By error, plot 33 received application of fertilizer for plot 35, at corn planting, 1885..
§ First applied to wheat, 1884-1885. ‖ 6 after 1884-1885. ¶ 8 after 1884-1885.

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Average Gains Over Unfertilized Plots. Wheat and Grass. 1888.

No.	Kind of Fertilizer.	Quantity of single fertilizer ingredients per acre.	Total quality of fertilizer per acre.	Number of plots.	Gain Over Unfertilized Plots.									Tier II.
					Average of previous crops 1882 1887					Tier III.				
					Wheat, 1882-1886.			Grass, 1883-1887, Hay.	Combined crops, 1882-1887.	Wheat, 1888.				Grass, 1888, Hay.
					Grain.	Straw.	Total crops.			Grain.	Straw.	Total crop.	Weight per bush.	
		Lbs.	*Lbs.*											
1	Nothing,			5										
2	Dried blood,	190	190	1	−61	90	29	275	246	121	251	372	1.0	−56
3	Dissolved bone black,	292	292	1	113	251	364	−283	81	−295	−453	−748	−2 2	624
4	Muriate of potash,	194	194	1	−46	−30	−76	−300	−376	−237	−351	−588	1.8	64
5	Dried blood, 190 Dissolved bone-black, 292	482	1	249	421	670	181	851	165	447	612	1 2	504	
6	Dried blood, 190 Muriate of potash, 194	384	1	−18	68	50	−492	−442	211	359	572	−1 2	304	
7	Dissolved bone-black, 292 Muriate of potash, 194	486	5	346	481	827	332	1,159	−93	−359	−452	−0 1	1,014	
8	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 190	676	13	324	776	1,100	325	1,425	117	273	392	−0.2	1,104	
9	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 380	866	2	474	1 026	1,500	454	1,954	451	1,081	1,532	−0.2	1,024	
10	Dissolved bone-black, 292 Muriate of potash, 194 Dried blood, 570	1,056	2	579	957	1 536	490	2,026	670	1,382	2 052	−2.5	434	
11	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 184	670	1	605	1,101	1,606	441	2,047	187	−55	132	0 3	384	
12	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 368	834	1	638	1,239	1,877	381	2,258	291	721	1,012	0 8	504	
13	Dissolved bone-black, 292 Muriate of potash, 194 Nitrate of soda, 552	1,038	1	650	720	1,370	369	1,739	827	1,785	2,612	1 3	64	
14	Dissolved bone black, 292 Muriate of potash, 194 Sulphate of ammonia, 124	610	1	597	974	1,581	944	2 506	327	845	1,172	−2 5	284	
15	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 248	784	1	851	1,540	2,391	929	3,320	487	1,565	2,052	−2 2	144	

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16	Dissolved bone-black, 292 Muriate of potash, 194 Sulphate of ammonia, 372	858	1	871	1,599	2,470	629	3,099	491	2,001	2,492	0 3	−736
17	Yard manure, 12,000	12,000	1	426	742	1 168	192	1.360	405	767	1.172	−0 7	804
18	Yard manure, 16 000	16,000	1	385	789	1 174	485	1,659	40:	737	1,140	0 5	464
19	Yard manure, 20 000	20,000	1	429	867	1,296	101	1 397	323	529	852	1 3	144
20	Yard manure, 12 000 Lime, 4 000	16,000	1	412	733	1 145	197	1 342	179	953	1,132	−1.2	464
21	Lime, 4 000	4.000	1	67	191	258	−36	222	307	25	332	0.3	−7:6
22	Ground limestone, 4 000	4,000	1	23	98	121	353	474	167	365	532	1.3	−896
23	Plaster, 320	320	‡2	−21	56	35	−147	−112	6	−154	−148	−0 1	494
24	Ground bone, 232 Muriate of potash, 194 Dried blood, 190	616	§2	−230	−180	−410	1,651	1,241	291	521	812	−0.5	434
	Average yield of plots receiving complete fertilizers containing—												
	Dried blood,		17	470	898	1,368	415	1.783	413	912	1 325	−0 7	854
	Nitrate of soda,		3	633	1.020	1 653	397	2,050	435	817	1 252	0 8	317
	Sulphate of ammonia.		3	770	1 371	2 141	821	2 962	435	1 470	1.905	−1 3	−109
	Nitrogen. 24 pounds per acre,		¶5	474	881	1.355	499	1,854	188	334	522	−0.5	714
	Nitrogen, 48 pounds per acre,		4	609	1 408	2.017	530	2 547	420	1.112	1 534	−0 5	674
	Nitrogen. 72 pounds per acre,		4	670	1,197	1.867	494	2 361	665	1 637	2.302	−0 5	49
	Yard manure,		4	353	799	1 152	859	2 011	327	747	1,074	−0.1	494

* 4 after 1884-1885. † 2 after 1884-1885. § First applied to wheat, 1884-1885. ‖ 6 after 1894 1895. ¶ 8 fter 1884 1885.

‡ By error, plot 33 received application of fertilizer for plot 35, at corn planting, 1885.

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The season of 1888 was favorable for wheat, and more than an average crop was obtained. It was free from the attacks of the fly, and made a good fall growth in 1887. The grain stooled well particularly on those plots receiving complete fertilizers. Those with sulphate of ammonia as a source of nitrogen had the best set of grain. At the time of cutting, the grain on all plots receiving complete fertilizers was well ripe; that on those plots receiving but one fertilizing ingredient was the greenest, and on the plot receiving lime it was also quite green.

The grass crop followed the wheat crop of 1887. It was the second crop removed after a single application of fertilizers. It was a mixture of timothy and clover. Timothy seed was sown with the wheat; the clover seed the following spring. It is interesting to note that while the wheat crop was a failure the grass crops following was below the average.

COMPARATIVE VALUE OF DIFFERENT FORMS OF PHOSPHORIC ACID—WHEAT, 1888.

BY H. P. ARMSBY AND W. H. CALDWELL.

The experiments described below were instituted with a view to testing the relative effect of some of the various forms of phosphoric acid in actual crop production as compared with their cost in the market. The experiments were planned by Prof. W. H. Jordan, professor of agriculture and agricultural chemistry in the college, and carried on by him up to the time of his resignation in 1885.

They were continued by his successor, Dr. Wm. Frear, and since the establishment of the Station have been in charge of Dr. Frear in 1887, and of Mr. Caldwell in 1888. On the other hand, the Director is wholly responsible for the methods here adopted in the discussion and interpretation of the results.

The experiments were made upon the ordinary four-course rotation of this section, viz: wheat, grass, corn and oats, the fertilizers being applied to the wheat and corn, and were preceded by an unmanured oat crop upon all the plots in 1883 for the purpose of testing the uniformity of the soil. Reports upon the progress of the experiments have been made from time to time in the reports and bulletins issued by the college* and in the last annual report of the Station† a summary for the first complete rotation of four years was given, to which reference may be had for any details as to the experiments which are not

*The Pennsylvania State College Report, 1883-4, p.—*Ibid.*, Report, 1886, pp. 124, 295, 321. *Ibid.*, Bulletin, No. 9.

† Report for 1887, pp. 69-84.

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included in the present report. This report is intended to record the results obtained with the wheat crop of 1888, and to bring the summary of the experiments up to date. Much of it is necessarily a repetition of the previous paper, but for the convenience of those who have not the former report it has been thought best to describe the experiment pretty fully, particularly the method of computing the possible errors involved.

UNIFORMITY TEST.

For the uniformity test of 1883, thirty-six plots were laid out on the Central Experimental Farm (now the Experiment Station Farm), contained in two series or tiers, running parallel to each other.

Each plot is one rod wide and eight rods long, containing one-twentieth of an acre, and is separated from the contiguous plots by a strip of land two feet wide.

The surface of the land has a slight inclination towards the south-east, which is nearly uniform for all the plots and is the direction of their length.

"The soil of the plots is a so-called limestone clay, formed from the decomposition of the surrounding and underlying rock, which is very largely magnesian limestone. It has the general appearance of a clayey loam."

During 1880 and 1881 the land was in grass (clover and timothy) and in 1882 in potatoes. No manure was applied to either crop. No recod has been kept to the yield of either hay or potatoes.

"No fertilizer was applied (1883) to any of these plots, and they were treated exactly alike as to manner and time of cultivation and quantity of seed." The seed was at the rate of two bushels per acre.

Only the first twelve plots of the first series, lettered from A to L, were used for the phosphoric acid experiments, and hence only the yields of these will be considered here. They were as follows:

Unmanured Oat Crop of 1883.

PLOT.	Grain, pound per acre.	Straw, pounds per acre.	Total, pounds per acre.
A,	1,400	2,900	4,300
B,	1,380	2,920	4,300
C,	1,480	2,720	4,200
D,	1,540	2,760	4,300
E,	1,620	2,880	4,500
F,	1,580	2,620	4,200
G,	1,540	2,460	4,000
H,	1,600	2,700	4,300
I,	1,680	2,420	4,100
J,	1,600	2,900	4,500
K,	1,840	3,160	5,000
L,	1,800	2,900	4,700
Average,	1,588	2,778	4,366

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In comparing these yields it must be remembered that the actual weights taken have been multiplied by 20 in order to express the results in pounds per acre, and that, therefore, differences of 20 to 40 pounds, corresponding to errors of one to two pounds in weighing are of little significance. Making all due allowance for this, however, it is evident that there were considerable irregularities in the yields of the individual plots. Plots K and L are notably in excess of the others, while the remaining plots show smaller variations.

CALCULATED UNMANURED YIELDS.

In order to know what effect, if any, is produced by the fertilizers used in a field experiment, it is plainly necessary to know how much the same plot would have produced if no fertilizer had been applied to it. For this purpose, plots F and L have been left unmanured throughout the experiment. Their yields were as follows, the yield of straw or fodder not being given separately, in order to avoid multiplying figures to a confusing extent:

Yield of Unmanured Plots, Pounds Per Acre.

	Grain.	Straw.	Total.
Plot F,	1,140	1,260	2,400
Plot L,	1,280	1,820	3,100

We cannot, however, assume that these results, or their average, represent what the other plots would have yielded had they also been unmanured, because the unmanured crop of 1883 showed that the plots were not uniform in natural fertility. The best we can do is to assume that the relative natural fertility of the plots remained the same, and that since the total yield of plot A, for example, was 102.4 per cent. of that of plot F, and 91.5 per cent. of that of plot L in 1883, the yield of A in 1884, if unmanured, would also have been 102.4 per cent. of that of plot F and 91.5 per cent. of that of plot L, and so with the other plots and the other years of the experiment.

Unfortunately, however, when we come to make this calculation we find that 102 4 per cent. of the yield of F is not equal to 91.5 per cent. of the yield of L, as it should be, owing to the fact that the yield of L varied relatively to that of F, as the experiment progressed. We therefore get two sets of figures for the calculated unmanured yields of the other plots, according to whether we make the yield of F, or that of L, the basis of calculation. These two sets of figures cannot both be right, but so far as appears one is as likely to be right as the other. The *most probable* figures are those obtained by averaging the two sets, and these average figures are the ones given in the following table. After each number is indicated how much it varies from the two others of which it is the average. Thus the total calculated yield of A, for 1884, is given in the table as $3,719 \pm 33$. This means that if we make the actual

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yield of plot L the basis of the calculation, as just explained, we find the calculated unmanured yield of A to be 3,719+35=3,752, while if we make the actual yield of plot F, the basis of the computation, we find the calculated unmanured yield of A to be 3,719−33=3,686. In other words, the figures following the sign ± do not denote what the mathematician calls "probable errors" but what we may call *possible errors;* that is, they show how much our average *may* vary from the truth owing to the uncertainty attaching to the method of calculating it.

Calculated Unmanured Yields on Basis of Oats, 1883, Pounds Per Acre.

	Grain.	Total crop.
A,	1,003±8	2,647±189
B,	989±8	2,647±189
C,	1,060±8	2,585±185
D,	1,103±8	2,647±189
E,	1,161±9	2,770±198
G,	1,103±8	2,463±175
H,	1,146±8	2,647±189
I,	1,204±9	2,524±181
J,	1,146±8	2,770±199
K,	1,318±10	3,097±242

THE MANURING.

Having now calculated as accurately as possible what we have reason to believe the plots whould have produced had they been left unmanured, we are prepared to consider the manuring and its effects.

The experiments were made in order to study the effects of different forms of phosphoric acid. To attain this end, it was necessary that the soil should contain all the other essential elements of plant food in sufficient amount. If potash, for example, were lacking or deficient in the soil, the crop would be a total or partial failure on all the plots, and the phosphoric acid would have no chance to produce an effect. To guard against this, all the plots except F and L (the unmanured plots) received 200 pounds of muriate of potash and 240 pounds of sulphate of ammonia per acre. They were thus supplied with nitrogen, potash, sulphuric acid and chlorine, while the limestone soil contained a vast excess of lime, magnesia and iron over what the crops could possibly use. Plots E and K received no other manuring. The remaining four pairs of plots were in addition manured as follows per acre:

A and G 200 lbs. dissolved bone black; the phosphoric acid largely soluble.

B and H 200 lbs. dissolved bone black, previously treated with lime; phosphoric acid largely reverted.

C and I 150 lbs. fine ground bone.

D and J 150 lbs. ground South Carolina phosphate; phosphoric acid largely insoluble.

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It was unfortunately not possible to analyze the fertilizers in these experiments, but they are all standard articles of trade, and on the basis of the average composition of these articles, the quantities above used were computed to contain about 32 pounds of phosphoric in the case of the dissolved bone black, the same reverted, and the ground bone, and about 39 pounds in the case of the South Carolina phosphate. The plots receiving the phosphoric acid in the insoluble form were to this extent given an advantage over the others. It should be added also, that ground bone contains more or less nitrogen, so that plots C and I received slightly more of this element than the others. With these two exceptions our four pairs of plots differ only in the *form* in which the phosphoric acid was applied. As before noted, the fertilizers were applied every alternate year, viz., in 1884 to the wheat and in 1886 to the corn. The succeeding hay and oat crops, therefore, show the residual effects of the previous year's application of fertilizers.

EFFECTS OF THE FERTILIZERS.

The following were the actual yields of the fertilized plots in 1888:

Yield Per Acre in Pounds. Wheat, 1888.

	Grain.	Straw.	Total.	Weight per bushel.
Plot A,	1,790	2,410	4,200	62¼
" B,	1,670	3,030	4,700	63½
" C,	2,065	3,235	5,300	60½
" D,	1,960	3,440	5,400	61
" E,	2,125	2,775	4,900	60¼
" G,	1,950	2,450	4,400	62½
" H,	1,750	2,940	4,700	63
" I,	2,100	2,900	5,000	61
" J,	1,860	2,840	4,700	61½
" K,	2,015	2,685	4,700	61½

By subtracting from these actual yields the calculated unmanured yields as given on p. 127 we find the gain due to the manuring, subject, of course, to the same possible errors as the calculated yields.

Gain Over Calculated Unmanured Yields.

	Grain.	Total.
A,	787±8	1,553±189
B,	681±8	2,053±189
C,	1,005±8	2,715±185
D,	857±8	2,753±189
E,	964±9	2,130±198
G,	847±8	1,937±175
H,	614±8	2,053±189
I,	896±8	2,476±181
J,	714±8	1,930±199
K,	697±10	160±242

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The above results show a large and unmistakable gain due to the use of fertilizers, as compared with the results on the plots remaining unmanured for five years. The difference between the results in the two series of experiments is not so marked as in previous years, but is still noticeable, the second series showing less favorable results than the first. For the present then we may continue to follow the plan of the previous year and consider the results of each series by themselves.

COMPARISON OF FORMS OF PHOSPHORIC ACID.

The last table shows the gain produced by the total manuring. The fertilizers on plots E and K, however, it will be remembered, contained no phosphoric acid. To get at the relative effects of the different forms, we must subtract from the total gains of plots with phosphoric acid, the gain made by the corresponding plot to which no phosphoric acid was applied. In the table below are the results of this calculation. It will be remembered that we are keeping the two series of plots distinct.

Gain Due to Phosphoric Acid.

PLOT.	Form of phosphoric acid.	WHEAT, 1888.	
		Grain.	Total crop.
A,	Soluble,	−177±17	−577±387
B,	Reverted,	−283±17	− 77±387
C,	Bone,	+ 41±17	+585±383
D,	Insoluble,	−107±17	+623±387
G,	Soluble,	+150±18	+334±417
H,	Reverted,	− 83±18	+450±431
I,	Bone,	+199±18	+873±423
J,	Insoluble,	+ 17±18	+327±441

In the grain we find four cases of gain and four of apparent loss. In the total crop we have six cases of gain due to the use of phosphoric acid and two cases of apparent loss. It is obvious that the effect of the phosphoric acid was not so marked this season as in previous years. It is more clearly seen in the figures for the total crop than in those for the grain, that is, it affected the growth of the straw more than that of the grain.

As regards the different forms of phosphoric acid the result is substantially the same as that reported last year; no one form is clearly indicated as superior to the others.

In such experiments as these, however, the average result for a series of years is likely to be more trustworthy than that obtained in any one year. For this reason, our conclusions last year were largely based on the combined results for the four years. In computing the possible errors of these combined results, however, an error was made

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in that they were assumed to be equal to the combined possible errors of the single years. It would appear more proper, however, to compare the total results for the four years in exactly the same way as the results for a single year, that is, to compute the unmanured yields on the basis of the total yields of the unmanured plots for the four years, and then to subtract these figures from the yields actually obtained. This method largely reduces the possible errors. Without going into the details of the computation, we may give the following table of the gains resulting from the use of phosphoric acid. It will be remembered that throughout we are treating each series of plots as a distinct experiment.

Gain due to Phosphoric Acid, 1884–87.

A,	2736±690
B,	3490±690
C,	3977±690
D,	2736±690
G,	843±771
H,	1129±796
I,	2707±777
J,	2205±806

Gain due to Phosphoric Acid, 1884–88.

A,	2101±295
B,	3355±295
C,	4505±295
D,	3301±295
G,	1174±400
H,	1574±410
I,	3572±400
J,	2525±415

On the basis of the above results we find that the various forms of phosphoric acid stand in the following order as regards their effects in these experiments:

4 YEAR AVERAGE.			5 YEAR AVERAGE,		
1st set.	2d set.	Average.	1st set.	2d set.	Average.
Bone,	Bone,	Bone,	Bone,	Bone,	Bone.
Reverted,	Insoluble,	Insoluble,	Reverted,	Insoluble,	Insoluble,
Soluble and Insol.,	Reverted,	Reverted,	Insoluble,	Reverted,	Reverted,
	Soluble,	Soluble,	Soluble,	Soluble,	Soluble.

The general result to be deduced from these summaries, and in which apparently we may place some degree of confidence, is that, upon our soil, and under our conditions, bone gave the best results and soluble phosphoric acid the poorest, while the insoluble and reverted forms were intermediate in value, sometimes the one and sometimes the

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other of these two excelling. It is not impossible that a continuation of the experiment may result in assigning a relative value to the insoluble and reverted forms.

It is to be remembered that the bone, as noted on page 128, contains some nitrogen and that some part of the effect here attributed to the phosphoric acid of the bone is really due to the nitrogen.

EXPERIMENTS ELSEWHERE.

The question of the relative agricultural value of the various forms of phosphoric acid is one which has been much discussed during the last ten years or more and in regard to which many experiments have been made. One general result of these experiments has been that, as is the case in our experiments, soluble phosphoric acid has shown no superiority over the less soluble forms *upon soils containing much lime*, while upon other soils it has usually surpassed the latter. We have not far to seek for the explanation of this fact. The advantage of soluble phosphoric acid lies in the more uniform distribution through the soil which results from its solubility. It is now well settled that it does not remain soluble in the soil for any great length of time, but is converted more or less rapidly into the reverted form. Thus Farsky mixed a superphosphate with soil and found that, within three hours, from 60 to 70 per cent. of its soluble phosphoric acid had reverted. In six hours the proportion was 67 to 80 per cent., in 12 hours 74 to 84 per cent., in 24 hours 80 to 88 per cent. From that point the process went on more slowly, and at the end of two weeks there was still 1 to 3 per cent. left in the soluble form. A superphosphate, then, does not act to any extent by furnishing to the plant a solution of phosphoric acid in water.

If we manure a soil with ground bone or ground phosphate rock, each minute a particle remains where the operations of tillage left it. and when we apply a few hundred pounds per acre and mix this with say the upper three or four inches of the soil, weighing in the neighborhood of a million pounds, it is plain that these particles, however small, must be left comparatively far apart. Where the particle is left, it lies. If a root chance to grow in its direction and come in contact with it, the particle is utilized. If not, it is dissolved and distributed but slowly by the soil water. A particle of a superphosphate under the same circumstances begins to be dissolved at once and rapidly by the soil water, forming a solution of phosphoric acid which tends to diffuse itself throughout the soil. True, the phosphoric acid is soon precipitated out of this solution, but not until it has spread through the soil for a greater or less distance. As a result, the soil is more or less impregnated with phosphoric acid throughout its whole extent, and wherever a root goes it finds more or less of this substance ready for assimilation. Moreover, the form in which it is precipitated

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from solution is probably more readily taken up by the roots of plants than is the insoluble acid of rock phosphate.

If, however, the soil contains much lime, the results are very much modified. Lime is one of the chief agents in precipitating the phosphoric acid out of its solution in the soil water. If large amounts of lime are present, it is precipitated almost as soon as dissolved, having no time to diffuse into the surrounding soil, and consequently is scarcely better distributed than the more insoluble form can be by tillage. As noted above, however, it would probably be somewhat easier of assimilation than rock phosphate. This rapid precipitation of the phosphoric acid by a limestone soil is well illustrated in the experiments of Farsky, already mentioned. When two lime soils were used, 98 per cent. of the phosphoric acid was precipitated in 48 hours in one case and in only 5 hours in another.

A lime soil, then, fails to get the full benefit of the soluble phosphoric acid of a superphosphate because it precipitates it too quickly, and so prevents its due distribution. There are two other classes of soils on which soluble phosphoric acid generally fails to give good results for an exactly opposite reason. Very light sandy soils, such as are commonly called leachy or hungry, and the soil of true peat bogs, consisting largely or almost wholly of decayed vegetable matter, stand at the other extreme from the lime soils, and have very little power to precipitate the phosphoric acid after it is dissolved. The result is that, if the drainage is good and the rainfall sufficient, the larger part of the acid is simply washed out of the soil and lost. On the other hand, in a dry season the phosphoric acid may remain in the soil, but its solution is liable to become so concentrated by evaporation as to actually injure vegetation. On these soils as well as on lime soils experiment has generally shown that the less soluble forms usually give as good or better results than the more costly soluble form.

As to other classes of soils the evidence is at present conflicting, some experiments apparently showing little difference between the value of soluble and reverted, while others show a striking difference. It is evident that much depends on local conditions, and the subject cannot be said to have yet reached a satisfactory solution.

The really insoluble form of phosphoric acid, such as the South Carolina phosphate used in our experiments, basic slag, etc., etc., has usually been found to be inferior, pound for pound, to soluble or reverted. In our own experiments, somewhat more phosphoric acid was applied in this form than in the others, but the possible errors are too great to permit of any exact comparison of its effects with those of the other forms.

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CONCLUSIONS.

A comparison of our results with those of others appears to justify the following conclusion:

Upon lime soils, upon very light sandy soils, and upon pure peat soils, the less soluble and cheaper forms of phosphoric acid are likely to prove equal or superior to the more costly soluble acid of the superphosphates.

This seems to be especially true of the reverted form, although in our experiments it appears not to have given as good results as the insoluble. As noted above, this is now rated in the valuation of fertilizers at but little less per pound than the soluble form. While this may be justified by present market prices, it can scarcely be doubted that, were there any call for this substance as such, it could be supplied at a much cheaper rate. Its most common commercial form is the so-called dicalcic phosphate, containing when pure 52.21 per cent. of phosphoric acid. Concerning this substance, Storer says (Agriculture, Vol. I, p. 278):

"This substance is prepared in Europe in a condition of almost absolute purity, and it could undoubtedly be imported either from England or from the Continent at small cost. In Europe the price of this precipitated phosphate is controlled by the price of bone ash, and the market value of a pound of phosphoric acid in the form of the precipitated phosphate is very nearly the same that it is when taken in the form of bone-ash."

"A somewhat less pure form of precipitated phosphate of lime has, for many years past, been made in England, France and Germany, in no inconsiderable quantities, as a product incidental to the manufacture of gelatine from bone."

In ground bone we have a form of phosphoric acid which, as the bone decays in the ground, is practically equivalent to reverted. To obtain good results from ground bone, however, the soil should be moist enough to favor its decay, yet not wet or heavy enough to exclude the air unduly. According to the fineness of the bone, its phosphoric acid costs from three to seven cents per pound. The finest is usually to be preferred. In addition to its phosphoric acid, ground bone contains more or less nitrogen, which adds to its value as a general fertilizer.

In the insoluble phosphates, such as South Carolina phosphate, basic steel slag, etc., phosphoric acid costs about two cents per pound, but, as stated, it seldom produces as good results, pound for pound, as the other forms. Presence in the soil of abundance of decaying vegetable matter favors its action, and fine grinding is essential. Within a short time very favorable results have been reported from the use of basic slag (from the Thomas-Gilchrist steel process), some experimenters rating it as high as the precipitated phosphate.

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In conclusion it should be remembered that local conditions greatly influence the action of fertilizers, often in a way we cannot as yet explain. Hence, any such general conclusions as those here stated should be tested with care when they involve a departure from established practices. A few simple and inexpensive trials of reverted or insoluble phosphates on a small scale would readily show one contemplating their use, whether they were likely to prove profitable under his circumstances.

The Station will gladly furnish any aid or information in its power to any who may desire to undertake such trials in this or any similiar matter.

EXPERIMENT ON THE PRODUCTION OF ROOT TUBERCLES.

BY WM. A. BUCKHOUT.

Some five years ago the writer began an examination of various leguminous plants for root tubercles. Not having access to the literature of the subject, and finding only a few brief notes on record in the books and periodicals at command, the work resulted in unconsciously going over the ground already known and recorded by different investigators. Starting with the garden pea, where these curious growths are conspicuous in size and number, they were found on other cultivated papilionaceæ, also beans, sweet peas, etc., and upon various wild species of *Vicia*, *Desmodium*, *Lespedeza*, etc. The examination of a considerable number of species of leguminosæ led to the conclusion that they were produced upon the roots of all papilionaceous species, even trees and shrubs, but probably not upon those of *Caesalpinea* or *Mimoseæ*. Of the latter, however, only a few examinations of *Gymnocladus dioicus* (Kentucky coffee tree). *Cercis Canadensis* (Red bud) and *Mimosa pudica* (sensitive plant) were made, and those not so fully as should have been done. Good material was hard to obtain.

In making microscopic examinations of the tubercles they were generally found to contain bacteria, but no attempt was made to determine whether they were the cause or merely accompaniments of the tuberculous growths. At this stage in the work various references to the investigations of others began to come to light, and it was evident that those points had already received much attention. Inasmuch as the further work of the investigators seemed to be directed chiefly toward the possible fungi which were the cause of the tubercles and to the relation which they bore to nitrogen assimilation—specially difficult lines of research—my attention was turned to a study of the conditions under which these bodies were formed.

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The garden pea was selected, and three kinds of cultures were undertaken, one in water, one in sand and one in ordinary soil. Distilled water, rain water and hard water respectively were used for watering purposes. The plots containing the sand and soil to be watered with distilled water were subjected to prolonged baking in an oven previous to being used. The water cultures were carried on in short wide-mouthed bottles, the seeds being supported on pieces of pumice or sandstone. In each case duplicates were taken to provide against loss or errors.

For convenience peas of the lowest and most compact growth were selected. The seeds were planted October 3, and kept in a cool greenhouse. Three examinations were made: November 3, when the plants were about three inches high; December 29, when they were in flower; and the last February 16, when they were in fruit. The three-inch pots proved rather small, and the plants became somewhat potbound, but this probably did not affect the result as regards development of tubercles. The plants were lifted with as little loss of root as possible, and the roots washed out in water.

An inspection of the following table shows the results:

A. Water cultures.
B. Sand culture.
C. Soil culture.
a. Use of distilled water (after heating pots to destroy all germs).
b. Use of rain water.
c. Use of hard or limestone water.

A. Water Culture.		B. Sand culture.		C. Soil culture.		
A. 1 *c.*	A. 2 *c.*	B. 1 *c.*	B. 2 *c.*	C. 1 *c.*	C. 2 *c.*	Examined Feb. 16, plants in fruit. Water cultures mostly dead, others declining (plants had become pot-bound). Two plants from each. ‡ † *—relative abundance.
A. 1 *b.*	A. 2 *b.*	B. 1 *b.* †	B. 2 *b.* †	C. 1 *b.* *	C. 2 *b.* *	
A. 1 *a.*	A. 2 *a.*	B. 1 *a.* *	B. 2 *a.* †	C. 1 *a.* *	C. 2 *a.* *	
A. 1 *c.*	A. 2 *c.*	B. 1 *c.*	B. 2 *c.*	C. 1 *c.*	C. 2 *c.*	Examined Dec. 29, plants in flower. Part of water cultured declining, others vigorous. One plant from each, ‡ † *—relative abundance.
A. 1 *b.*	A. 2 *b.*	B. 1 *b.* †	B. 2 *b.* *	C. 1 *b.* †	C. 2 *b.* †	
A. 1 *a.*	A. 2 *a.*	B. 1 *a.* *	B. 2 *a.* *	C. 1 *a.* †	C. 2 *a.* †	
A. 1 *c.*	A. 2 *c.*	B. 1 *c.*	B. 2 *c.*	C. 1 *c.*	C. 2 *c.*	Examined Nov. 3, plants three inches high, all vigorous. One plant from each, ‡ † *—relative abundance of tubercles.
A. 1 *b.*	A. 2 *b.*	B. 1 *b.*	B. 2 *b.* †	C. 1 *b.* †	C. 2 *b.*	
A. 1 *a.*	A. 2 *a.*	B. 1 *a.* †	B 2 *a.* ‡	C. 1 *a.* †	C. 2 *a.*	

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The water cultures developed rather poorly, though some gave as vigorous and long lived plants as any others.

It is evident that

(1.) No tubercles appeared in any of the water cultures.

(2.) None appeared in either sand or soil watered with distilled water.

(3.) They are more abundant from and after the time of flowering than before.

(4.) There is no marked difference between the number occurring in clear sand and in soil.

HORTICULTURAL REPORT.

BY GEORGE C. BUTZ.

The horticultural work of the Station is a new feature in this region. Much agricultural experimentation has been conducted here for the past twenty years so that the possibilities of the soil and location in that line of work is tolerably well known. The past year's records in garden work being the only data we have to consider, no safe conclusions can be drawn from our results, except possibly in regard to the comparative value of varieties. A large number of varieties having been grown side by side, with practically the same soil, treatment and atmospheric conditions. Many of these varieties are old and well known to most gardeners and farmers of the State, and as few gardeners ever plant more than four or five sorts of a vegetable at one time, the records in this report will be found to contain such facts as are desirable in selecting a new or better variety. The soil of the Station garden is quite uniform, but not of that character which is most likely to promote vegetable growth. It has been cultivated many years previous for farm crops, with occasional light manurings; but, being a cold, heavy, clay, only a little darker than the subsoil, it will require several years heavy manuring and cultivation to bring it into a good condition for garden purposes. The land has a slight southeasterly slope, rising but little to the northwest, and there is no protection or wind-break in the immediate neighborhood of the garden. The seeds used were purchased directly from seedsmen, except those obtained from the United States Department of Agriculture. Some of the former, as well as of the latter, failed to germinate in our soil, although they showed a germinative power of sixty per cent. in the germination tests of the early spring, as recorded in Bulletin No. 4. Prominent among these failures were the seeds of gherkin cucumbers from both sources.

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The garden plot is particularly free from troublesome weeds. Under the head of "weeds," in this report, will be found a list of all the weeds that have appeared on a plot one-twentieth of an acre in extent, located not far from the garden, but many of that list were not seen in the latter place.

In regard to small fruits, nothing has been done this year, except with grapes, as no plants of other fruits were set out and none are yet in the possession of the Station. However, the extent to which small fruits are cultivated in this State, renders it important that the attention of the Station be given to this branch of horticulture, and we shall add the necessary material to our resources during the coming year.

BUSH BEANS.

Seeds of bush beans were sown in drills in the garden May 28, and nearly all varieties had vegetated by June 7. It is observed that in a heavy soil the plantlet in pushing through frequently has the misfortune to break off its plumule, and, also, a late frost often nips the plumule that has just appeared. To show the effect of such accidents upon the growth of the plants, the following experiment was conducted: Seeds of variety No. 1564 were sown June 1, and these vegetated June 11. The plumules of forty plants were cut off just above the node of the seed leaves; seven days later axilary buds appeared in the axils of the cotyledons. On July 15 the plants of this sowing which were not deprived of their plumules showed first flower, while those operated upon showed first flower July 22. Marketable pods were obtained from the former July 20, and from the latter August 4. However, the want of thrift in the injured plants condemn the practice of allowing such plants to grow where a second sowing can be made. But a very few plants of any species will form branches from the axils of the cotyledons unless forced to do so, and even then the growth is not vigorous. The experiment was extended to the squash, melon and cucumber, all of which grew, but not so far as to yield fruit.

In the table of bush beans will be found such facts as are most important in the selection of a variety for any purpose. Earliness is frequently the strongest recommendation. The length of time during which good edible pods may be found on the plants must be considered. The productiveness of the different varities varies greatly; as the figures indicate, it ranges anywhere between twelve and one hundred grammes per plant. Lastly, the color of the pod will assist in selecting a desirable variety.

Broad Windsor and Early Magazan are of the English dwarf type and must be sown early in order to mature before the heat of summer interferes with them. These two varieties were sown April 26, but gave no satisfactory yield, owing to the early and excessive attack of

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the plant louse, which troubles these plants everywhere. Landreth's Violet, a light yellow pod, showed little tendency to spot, remaining remarkably free from that disease. The yield of that variety was the greatest this year, of the whole list tested.

The best showing among the new varieties grown this season was made by the New Prolific German Wax, No. 1596. It combines several merits; it is early, productive, yellow in color, keeps well on the plants and is a pretty pod in a basket. At the time of recording the description of this plant, there were twenty-eight mature pods on it, a number that is surprisingly large, since other varieties held from seven to fifteen pods each.

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Bush Beans.

Station number.		Seeds from.	First flower.	First marketable pods.	Days from planting.	Last marketable pods.	Number of days marketable.	Average yield per plant in grams.	Color of pods.
1576	Black Eyed Wax,	Landreth,	July 4,	July 18,	51	August 11,	24	60	Yellow.
1272	Brown Speckled Valentine or Refugee,	"	" 20,	Aug. 6,	70	" 18,	12	46.5	Light green.
1286	Broad Windsor,	"	June 11,	July 2,	67	. . . . .	. . . . .	. . . . .	Green.
1265	China Red Eye,	"	July 5,	" 19,	52	August 6,	18	18.6	Green.
1262	Crystal Wax,	"	" 19,	" 31,	64	" 15,	15	35.3	White.
1575	Detroit Wax,	Ferry,	" 6,	" 16,	49	" 10,	25	56.5	Yellow.
1574	Dwarf Horticultural,	Ferry,	" 6,	" 18,	51	" 6,	19	15.2	Green.
1268	Dwarf German Wax,	Landreth,	" 4,	" 18,	51	" 10,	23	55.7	Yellow.
1266	Extra Early Red Valentine,	"	" 6,	" 19,	52	" 12,	24	60.2	Green.
1276	Early Brown Six Weeks,	"	" 5,	" 19,	52	" 12,	24	71.3	Green.
1287	Early Magazan,	"	June 13,	" 2,	67	. . . . .	. . . . .	. . . . .	Green.
1261	Golden Wax,	"	July 5,	" 19,	52	August 6,	18	21.5	Yellow.
1271	Ivory Pod Wax,	"	" 14,	" 27,	60	" 13,	17	53.2	White.
1260	Landreth First in Market,	"	" 5,	" 19,	52	" 6,	18	12	Green.
1269	Landreth Scarlet,	"	" 7,	" 17,	50	" 8,	22	46	Yellow.
1270	Landreth Violet,	"	" 7,	" 20,	53	" 11,	22	98.5	Yellow.
1264	Long Early Yellow Six Weeks,	"	" 5,	" 19,	52	" 6,	18	18.6	Yellow.
1267	Navy Bush,	"	" 14,	" 30,	63	" 13,	14	50.6	Green.
1596	New Prolific German Wax,	Vick,	" 5,	" 17,	50	" 13,	27	68.5	Yellow.
1274	Red Speckled Valentine,	Landreth,	" 8,	" 19,	52	" 15,	27	42	Green.
1273	Royal Dwarf,	Landreth,	" 15,	" 21,	54	" 15,	25	55.7	Green.
1569	Scarlet Flageolet Wax,	Ferry,	" 11,	" 20,	53	" 12,	23	67.5	Yellow.
1563	Thorburn's Extra Early Refugee.	Thorb.	" 6,	" 21,	54	" 8,	18	37.9	Light green.
1564	Thorburn's Extra Early Flat Bush,	Thorb.	" 6,	" 18,	51	" 9,	22	37.8	Light green.
1568	Violet Flageolet Wax,	Ferry,	" 7,	" 20,	53	" 11,	22	63.8	Yellow.
1263	White Cranberry,	Landreth,	" 18,	" 30,	63	" 13,	14	37.5	Green.
1275	White Valentine,	Landreth,	" 7,	" 20,	53	" 12,	23	58	Green.

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POLE BEANS.

These were grown in hills in the garden, with from three to five plants to the hill; the yield is given per hill instead of plant, as in the table of bush beans. The seeds of all the pole beans were planted May 29. The greater number of these varieties yielded their full crop before they were injured by frost, but those having their last marketable pods recorded on October 6 and after, were cut short by a frost appearing on that date.

Special attention might be called to the Southern Prolific as an excellent bean with a tender pod, very productive, though late. A fuller description of this bean may be of value here, as two very different ones have been sold under the same name. The vine is vigorous, growing eight to ten feet long, leaves dark green; the pods, in clusters of six to ten, are round, almost straight, green, very brittle and tender, with seven to nine ovules to the pod, length of pods five inches. The Painted Lady is somewhat similar to the Scarlet Runner, having large scarlet flowers. One vine of this variety produced all white flowers, and being as large as the scarlet ones, made a pretty comparison for the latter as to floral excellence.

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Pole Beans.

Station number.		Seeds from.	First flower.	First marketable pods.	Days from planting.	Last marketable pods.	Number of days marketable.	Average yield per "hill," in grams.	Color of pods.
1277	Carolina or Sewee,	Landreth,	July 30,	Aug. 15,	79	Oct. 15,	61	118	Green.
1279	Creaseback,	"	" 16,	" 4,	68	Aug. 29,	25	471	"
1284	Cream Seeded Cut Short,	"	" 30,	" 10,	74	Sept. 15,	31	1773.5	"
1562	Dreer's Golden Cluster Wax,	Thorburn,	" 27,	" 9,	73	Sept. 15,	37	1288.5	Yellow.
1570	Extra Early Lima,	Ferry,	" 24,	" 15,	79	Oct. 10,	56	135	Green.
1594	Early Golden Cluster Wax,	Vick,	" 30,	" 13,	77	Sept. 18,	36	887.5	Yellow.
1595	Extra Early Lima,	Vick,	" 27,	" 17,	81	Oct. 6,	50	25	Green.
1282	Giant Wax,	Landreth,	" 30,	" 10,	74	Sept. 20,	41	835	Yellow.
1281	Horticultural,	Landreth,	" 24,	" 7,	71	Sept. 3,	27	442	Green.
1593	King of the Garden Lima,	Vick,	" 27,	" 16,	80	Oct. 4,	49	140.5	"
1288	Large Lima,	Landreth,	" 23,	" 16,	80	Oct. 6,	51	141	"
1278	New White Seeded Runner,	"	" 27,	" 11,	75	Sept. 19,	39	717	Yellow.
1285	Oval Red Speckled Cut Short,	"	Aug. 4,	" 25,	89	Oct. 4,	40	299	Green.
1703	Painted Lady,	U. S. Dep. Agr.,	July 6,	" 8,	72	Oct. 12,	65	1060	"
1572	R. I. Creaseback,	Ferry,	July 27,	" 7,	71	Sept. 20,	44	1589	"
1571	Southern Prolific,	Ferry,	Aug. 10,	" 27,	91	Oct. 6,	40	1956	"
1702	Tall Mt. d'Or,	U. S. Dep. Agr.,	July 22,	July 31,	64	Aug. 24,	24	209	Yellow.
1283	Tall German Wax,	Landreth,	Aug. 3,	Aug. 9,	73	Sept. 14,	36	245	Yellow.
1280	White Dutch or Case-knife,	Landreth,	July 20,	" 4,	68	Sept. 15,	42	953	Green.
1573	White Creaseback,	Ferry,	July 19,	" 2,	66	Aug. 27,	25	416	Green.

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BEETS AND CARROTS.

The seeds of these vegetables were sown in drills in the garden, allowing a length of fifteen feet to each variety. The heavy nature of our garden soil is certainly not adapted to produce early crops, but we in time obtained some very fine roots of beets and carrots, possessing an excellent flesh. The beets were remarkable for their regularly good form and the clean, smooth surface of the roots. The Eclipse beet, sent us by the Department of Agriculture, was a somewhat different beet from that of the same name from Landreth. The form of root and foliage was about the same in each, but the flesh of Landreth's was colored in distinct rings, alternating dark red and pink, while in that from the Department of Agriculture the flesh was colored a carmine red mottled with white. The latter was considered the superior beet in tenderness and flavor.

The following varieties of carrots—Extra Early Forcing, Early Scarlet Horn, Chetenay Half Long and Early Forcing—have a sweet flavor and make good table vegetables; the rest of the list given are rather bitter, and especially the Long Cassaby.

Beets.

Station number.		Seeds from.	First roots marketable.	Days from planting.	Color of flesh.
1329, . .	Bassano, ...	Landr., ...	July 18, .	78	Salmon and white.
1327, . .	Eclipse, ...	"	" 11, .	76	Red and pink.
1728, . .	Eclipse, ...	U. S. Dept. Agr.,	" 6, .	71	Red and white.
1332, . .	Early Blood Red Turnip, . . .	Landr., ...	" 18, .	83	Red and pink.
1328, . .	Egyptian Turnip, ...	"	" 10, .	75	" "
1333, . .	Half Long Blood Red, . . .	"	" 14, .	79	" "
1337, . .	Imperial Sugar, ...	"	" 17, .	83	White.
1330, . .	Landreth's Very Early, ...	"	" 18, .	83	Violet and white.
1334, . .	Long Blood Red, ...	"	" 21, .	86	Red and pink.
1724, . .	Osborn's Selected, ...	U. S. Dept. Agr.,	" 11, .	76	" "
1331, . .	Phila. Early Turnip, ...	Landr., ...	" 16, .	81	Red and white.
1323, . .	" Perfection, ...	"	" 18, .	83	Violet and white.
1336, . .	Silesian Sugar, ...	"	" 16, .	81	White.

Carrots.

Station number.		Seeds from.	First roots marketable.	Days from planting.	Color of flesh.	Length of root—inches.
1317, . .	Chatenay Half Long,	Landr., ...	August 6, .	102	Orange scarlet,	5
1715, . .	Early Forcing, ...	U. S. Dept. Agr.,	" 8, .	104	" yellow,	2.5
1376, . .	" Scarlet Horn,	Landr., ...	July 31, .	96	" "	7
1375, . .	Extra Early Forcing,	"	" 31, .	96	" "	1.5
1378, . .	Long Orange, ...	"	August 6, .	102	" "	8
1379, . .	" White Belgian,	"	" 6, .	102	White, ...	10
1380, . .	" Giant White, . .	"	" 6, .	102	" . .	10
1714, . .	" Cassaby, ...	U. S. Dept. Agr.,	" 6, .	102	Orange yellow,	11

CABBAGE.

In some respects the yield of cabbages was not as good as we expected. It will be observed from the table that the "first heads" were universally late, which fact we can attribute to the heavy, cold

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nature of the garden soil. At the time of setting out, the plants were uniformly in fine condition. The early varieties were sown in shallow seed boxes April 4, and kept in the greenhouse where the seed vegetated in about four days. On April 24 the young plants were transplanted to a hotbed of which the soil was not so light and loose as that commonly used in hotbeds, and the plants instead of becoming long and tender, grew up with stout stalks and good leaves. Fifteen good plants of each variety were transplanted to the garden on May 15.

Many varieties will yield a good head to each plant set out, while others can never be depended upon for more than seventy-five per cent of good heads. Bloomsdale Bullock Heart is a good round head, combining size and earliness. Winningstadt, so extensively grown, ranks among the best early cabbages. Large Jersey Wakefield showed a very early tendency to "split." Of the newer sorts *All Seasons* we have recorded as a comparatively large head, early and holds well without splitting. *Early Express* is a good early cabbage, but not a large head. *Very Early Etampes* is a large pointed head resembling Wakefield, and is a good cabbage, if it can be cut soon after becoming solid, as it splits shortly after. Buncombe, Extra Early Pointed Market, Stone Mason and Berkshire Beauty have very large heads with broad spreading leaves. They are all good cabbages.

The *late cabbages* gave more general satisfaction in heading. The seeds were sown in a spent hotbed April 28, and the plants were set out June 21st in the garden. Good heads were formed on all the varieties given in the table, but no dimensions were recorded.

Cabbage—Early.

Station number.		Seeds from.	First marketable heads.	Days from planting in garden.	Diameter of head in inches.
1549	All Seasons,	Thorb.,	Aug. 6,	83	6
1355	Bloomsdale Bullock Heart,	Landr.,	" 5,	82	8
1359	" Early Market,	"	" 11,	88	5
1362	" " Dwarf Flat Head,	"	" 6,	83	9
1364	" " Drumhead,	"	" 4,	81	7
1738	Buncombe,	U. S. Dept. Agr.,	" 11,	88	6
1736	Berkshire Beauty,	" "	" 16,	98	8
1350	Early York,	Landr.,	" 10,	87	5
1354	" Sugar Loaf,	"	" 10,	87	4
1356	" Cone,	"	" 7,	84	6
1363	" Flat Dutch,	"	" 18,	90	8
1366	" Drumhead,	"	" 13,	90	6
1550	" Express,	Thorb,	" 6,	82	5
1734	Extra Early Pointed Market,	U. S. Dept. Agr.,	" 5,	82	7
1358	French Oxheart,	Landr.,	" 16,	98	6
1367	Filderkraut,	"	" 18,	90	5
1348	Landreth's Earliest of all,	"	" 28,	100	6
1351	" Large York,	"	" 20,	97	4
1356	" Early Summer Flat Head,	"	July 31,	77	7
1360	Large Jersey Wakefield,	"	Aug. 6,	88	6
1365	Long Island Medium Flat Dutch,	"	" 16,	98	8
1361	N. Y. Early Summer,	"	" 6,	88	8
1352	Reedland's Early Drumhead,	"	" 11,	88	5
1349	Select Very Early Jersey Wakefield,	"	" 13,	90	6
1735	Stone Mason,	U. S. Dept. Agr.,	" 23,	100	8
1596	Very Early Etampes,	Ferry,	July 30,	76	7
1357	Winningstadt,	Landr.,	Aug. 6,	88	6

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Cabbage—Late.

Station number.		Seeds from.	First marketable head.	Days from planting to garden.
1868,	Bloomsdale Large Late Flat Dutch,	Landr.,	Sept. 18,	89
1872,	Drumhead Savoy,	"	" 7,	78
1869,	Large Drumhead,	"	" 20,	91
1870,	Landr. Large Late Mountain,	"	" 22,	93
1871,	Mammoth Bergen,	"	Oct. 12,	113
1851,	M. G. Large Late Flat Dutch,	Thorb.,	" 10,	81
1874,	Red Dutch,	Landr.,	" 5,	76

CAULIFLOWER.

Several varieties of this vegetable were sown and planted along with the early cabbage, and others with the late cabbage. No good heads were formed on the early sorts except on those plants that lingered into the later season before beginning to head.

No. 1584 *Gilt Edge Snowball* matured its first good head, eleven inches in diameter, July 31. It was free from the numerous leaves through the head that make the ordinary early cauliflowers so unsightly.

Algiers and Imperial Novelty yielded excellent heads in November among the late sorts of the garden.

CUCUMBERS.

The seeds were planted in hills in the garden and required from ten to fifteen days to vegetate in our heavy soil. To obtain the yield all the fruits were cut as fast as matured from three good hills and weighed. This cutting as soon as fully formed allowed more nourishment for the development of new fruits. The figures in the last column of the table are for one hill. Among the new varieties *Florida's Emerald* gave the greatest satisfaction and is a very distinct cucumber. The form of the fruit is long and cylindrical, length, nine inches; diameter, two and a half inches. The skin is almost smooth, of a beautiful green color. Thorburn's New Everbearing is a new variety, of which we received but five seeds, and only one plant was obtained from them. This produced several good, well-formed fruits and then died.

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Cucumbers.

Station number.		Seeds from.	First flower.	First marketable fruit.	Days from seeding.	Weight of average fruit in grams.	Yield per hill in grams.
1579	Arlington,	Ferry,	July 20,	Aug. 11,	72	442	2516
1257	Boston Pickling,	Landreth,	" 16,	" 5,	68	200	1138
1580	Chicago,	Ferry,	" 13,	" 3,	64		330
1253	Early Choice,	Landreth,	" 16,	" 6,	67	410	1634
1254	Early White Spine,	Landreth,	" 20,	" 6,	67	280	2272
1720	Early Forcing,	U. S. Dept. Agr.	" 20,	" 11,	72	395	2443
1554	Extra Early Seedling,	Thorb.,	" 11,	" 2,	63	118	1200
1555	Florida's Emerald,	Thorb.,	" 22,	" 6,	67	440	1805
1251	Landreth's First,	Landreth,	" 17,	" 6,	67	240	1542
1252	Landreth's Choice,	Landreth,	" 29,	Sept. 5,	97	260	783
1255	Landreth's White Slicing,	Landreth,	" 20,	Aug. 6,	67	495	3353
1553	Large Russian Netted,	Thorb.,	" 14,	" 3,	64		1311
1258	Long Green Turkey,	Landreth,	" 16,	" 6,	67		917
1722	Nichols' Medium Green,	U. S. Dept. Agr.	" 14,	" 6,	67		885
1256	Short Prolific Pickle,	Landreth,	" 17,	" 4,	65		453
1810	Thorburn's New Everbear'g,	Thorb.,	" 13,	" 14,	75		

CORN.

No satisfactory results were obtained from the corn in the matter of good ears and yield, owing probably to the fact that most of it grew in a single row, and the general direction of the wind being across the row, the pollen was carried away and the ears were consequently imperfectly fertilized. The seeds were planted May 21, in hills two feet apart. The earliest varieties were Marblehead and Cory; of the latter, seeds from two sources were planted and about the same results were obtained, yielding marketable ears in seventy-seven days from planting. The Black Mexican, having purple black grains, is a good flavored corn, though coming late.

Sweet Corn.

Station number.		Seeds from.	First marketable ears.	Days from sowing.	Last marketable ears.
1311	Adam's Extra Early,	Landreth,	August 12,	98	September 17
1312	Adam's Early,	"	" 25,	96	" 6
1738	Breck's Premier,	U. S. Dep. Agr.,	" 24,	95	" 1
1323	Black Mexican,	Landreth,	September 1,	108	" 21
1322	Cory Sugar,	"	August 6,	77	" 1
1610	Cory Sweet,	U. S. Dep. Agr.,	" 8,	79	" 4
1310	Eight Rowed,	Landreth,	" 27,	98	" 17
1313	Early Landreth's Market,	"	" 18,	89	" 5
1317	Early Crosby,	"	" 29,	100	" 7
1318	Early Concord,	"	September 5,	107	" 14
1321	Early Mammoth,	"	August 29,	100	" 15
1326	Egyptian Sugar,	"	September 15,	117	" 28
1612	Egyptian Sweet,	U. S. Dep. Agr.,	" 8,	105	" 20
1314	Extra Early Narragansett,	Landreth,	August 18,	89	August 30
1315	Extra Early Minnesota,	"	" 28,	99	September 3
1615	Golden Yellow Sweet,	U. S. Dep. Agr.,	" 25,	96	" 10
1611	Improved Evergreen,	" "	September 8,	105	" 21
1325	Late Mammoth,	Landreth,	" 18,	120	" 26
1319	Landreth's Sugar,	"	August 28,	99	" 16
1316	Marblehead Sugar,	"	" 6,	77	August 30
1712	Perry's Hybrid,	U. S. Dep. Agr.,	" 29,	100	September 15
1324	Stowell's Evergreen,	Landreth,	September 8,	110	" 20
1613	Stabler's Early,	U. S. Dep. Agr.,	" 1,	103	" 20
1320	Triumph Sugar,	Landreth,	August 25,	96	" 29

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LETTUCE.

Seeds of the lettuce were sown in the garden drill May 2, and most of it vegetated by the 10th of the same month; later it was thinned out to allow the formation of large heads without crowding.

Landreth's Earliest Cutting proved true to its name, but, forming a small head and soon shooting to seed, it is not as valuable to the market gardener as many of the larger-headed later varieties. In the last column of the table of lettuce is given the form of the head, whether loose with leaves upright or in the shape of a cabbage head. Defiance is a good summer lettuce. It will be seen from the table that its period of cutting was longer than that of any other sort. Buttercup has an attractive head, because of the greenish-yellow color of its leaves. The head is of a fair size, and being solid, it makes a good market sort. Deacon proved to be a very large, solid green head, eleven inches in diameter, matured early and did not shoot to seed for twenty days after. White Chavigne yielded the largest head in our whole list, measuring sixteen inches in diameter (extreme of outer leaves) and weighing seven hundred and twelve grammes. The seed was obtained from the United States Department of Agriculture. It was badly mixed with seed of varieties similar to Deacon, Brown Dutch and White Paragon.

Lettuce.

Station number.		Seeds from.	First head marketable.	Days from sowing.	Last head marketable.	Weight of fair head in grams.	Character of top.
1398	Blomsdale Reliable,	Landreth,	July 4,	63	Aug. 2,	315	Head.
1405	Bloomsdale Early Summer,	Landreth,	" 7,	66	" 6,	224	Head.
1406	Boston Market,	Landreth,	" 3,	62	July 17,	62	Loose.
1411	Brown Dutch,	Landreth,	" 20,	79	Aug. 2,	185	Loose.
1541	Buttercup,	Thorburn,	" 16,	75	" 18,	121	Head.
1385	Buttercup,	Ferry,	" 12,	71	" 10,	165	Head.
1536	Defiance,	D. eer,	" 8,	67	" 16,	187	Loose.
1388	Deacon,	Ferry,	" 2,	61	July 30,	267	Head.
1402	Early Curled Silesian,	Landreth,	" 24,	88	Aug. 1,	368	Loose.
1403	Early Simpson,	Landreth,	" 4,	63	July 31,	335	Loose.
1409	Green Cos,	Landreth,	" 13,	72	" 28,	271	Head.
1408	Hanson,	Landreth,	" 4,	63	Aug. 4,	335	Head.
1399	Landreth's Forcing,	Landreth,	" 7,	66	" 1,	143	Loose.
1400	Landreth's Earliest Cutting,	Landreth,	" 1,	60	July 18,	87	Loose.
1540	M. G. Private Stock,	Thorburn,	" 8,	67	Aug. 1,	161	Head
1401	Simpson,	Landreth,	" 4,	63	July 31,	342	Loose.
1404	Tennis Ball,	Landreth,	" 2,	61	" 15,	72	Loose.
1407	Very Select Curled India,	Landreth,	" 4,	63	Aug. 3,	370	Head.
1410	White Cos or Ice,	Landreth,	" 5,	64	" 8,	527	Loose.
1718	White Chavigne,	U. S. Dep't. Agr.	" 5,	64	" 2,	712	Head.
1719	White Paragon,	U. S. Dept. Agr.	" 4,	63	July 30,	319	Loose.

PEAS.

Over thirty varieties of peas were sown in the garden on the 26th of April, devoting thirty feet of drill to each variety. All the tall varieties were staked by using split stakes two to three feet long every ten feet, with strong twine stretched along either side of the vines from one stake to the other. This method held the vines in a way

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that made picking easy. The vines were all left to ripen seed, and it was remarkable how little mildew appeared this year.

The figures in the following table will serve better than full descriptions of the varieties, to guide those persons wishing to select such varieties as will best meet their wants. It is not advisable to select a sort that is claimed to answer every want. It remains with each grower to decide if he desires especially a pea that is early, or late, tall or dwarf, productive, or of a long period of usefulness. All of these points can be found in the table below.

Telephone is a remarkably good producer, and even though it requires the extra labor of "staking," the return in yield will over-balance the expense of the extra labor. The pods and seeds are quite large. *Earliest of All*, of late introduction, is another good pea among the early sorts. Special attention may be called to No. 1711 *Perpetual*. The seed of this was sent to the Station from the United States Department of Agriculture. Although sown at the same time as the others, the first pods were picked as late as July 14, but the yield was immense, continuing until August 15th. The vines are strong and vigorous.

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Peas.

Station number.		Seeds from.	First flower.	First marketable pods.	Days from sowing.	Last marketable pods.	Height of plants in inches.	Yield of 50 plants in grams.	Number of seeds to a pod.
1298,	Alpha,	Landreth,	June 6,	June 21,	56	July 6,	48	701	6
1297,	American Wonder,	"	" 6,	" 28,	58	" 2,	7	340	6
1301,	Blue Peter,	"	" 6,	" 22,	57	" 2,	10	425	5
1306,	Bishop's Early Long Pod,	"	" 18,	July 6,	71	" 28,	24	781	7
1708,	Blue Peter,	United States Department Agriculture,	" 6,	June 21,	56	" 2,	8	569	. . . . .
1294,	Champion of England,	Landreth,	" 18,	" 30,	65	" 14,	48	975	8
1304,	Day's Sunrise,	"	" 14,	July 4,	69	" 12,	28	1,183	8
1291,	Early Dan'l O'Rourke,	"	" 5,	June 8,	43	" 2,	21	325	5
1589,	Earliest of All,	Ferry,	" 5,	" 20,	55	" 2,	20	351	5
1706,	Emerald Gem,	United States Department Agriculture,	" 9,	" 28,	58	" 6,	20	1,244	6
1292,	Eugenie,	Landreth,	" 7,	" 30,	66	" 6,	26	915	4
1299,	First Crop,	"	" 6,	" 20,	55	June 30,	22	402	6
1303,	French Canner,	"	" 18,	" 30,	65	July 6,	28	433	8
1305,	Forty-Fold,	"	" 15,	" 30,	65	" 17,	32	738	7
1707,	Fillbasket,	United States Department Agriculture,	" 18,	July 4,	69	" 27,	35	833	6
1295,	Improved Dan'l O'Rourke,	Landreth,	" 6,	June 20,	55	" 2,	24	425	6
1293,	Kentish Invicta,	"	" 6,	" 20,	55	" 8,	29	433	6
1705,	Maud S,	United States Department Agriculture,	" 5,	" 18,	53	June 30,	20	315	4
1590,	McBeth's Pride,	Ferry,	" 5,	" 20,	55	July 2,	15	402	. . . . .
1302,	McLean's Advancer,	Landreth,	" 9,	" 28,	58	" 6,	22	519	4
1289,	" Little Gem,	"	" 9,	" 21,	56	" 6,	16	550	5
1296,	Phila. Extra Early,	"	" 6,	" 19,	54	June 30,	24	257	5
1309,	Purple Blossom Sugar,	"	" 18,	July 3,	68	July 11,	18	879	7
1281,	Pride of the Market,	"	" 18,	" 3,	68	" 14,	15	914	9
1709,	" " "	United States Department Agriculture,	" 18,	" 5,	70	" 17,	26	1,186	. . . . .
1704,	Prize Taker,	" " " "	" 6,	" 7,	73	" 22,	40	714	. . . . .
1711,	Perpetual,	" " " "	" 9,	" 14,	79	August 15,	42	1,505	. . . . .
1710,	Rural New Yorker,	" " " "	" 5,	June 20,	55	July 6,	24	551	7
1308,	Royal Dwarf Marrowfat,	Landreth,	" 18,	July 5,	70	August 6,	33	832	4
1307,	Tall Sugar,	"	" 20,	" 5,	70	July 19,	40	889	7
1300,	Tom Thumb,	"	" 7,	June 21,	56	" 2,	7	238	5
1290,	Telephone,	"	" 16,	July 2,	67	" 15,	26	1,500	6

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RADISH.

Over thirty varieties of radishes were grown in the garden. The seeds were sown in drills, allowing thirty feet to each variety. At the time of sowing, May 2d, the ground was in good condition and with considerable moisture following. There was reason to expect good radishes. In the table below will be found the dates of the first and last marketable roots of each sort, indicating the length of time through which good roots may be pulled. In dry seasons this time may be limited to two or three days with some varieties, and often no good roots would be formed without irrigation.

Of the new varieties tested, the *Philadelphia White Box* introduced by Vick, showed itself to be a valuable white radish, the leaves only four inches long, the root of the globe type, solid, white and mild. No radishes were grown in frames this year, so that we cannot speak of the merits of these new varieties for frame culture, but from all indications the above-named sort ought to be a good radish for early market. *Ne Plus Ultra* did not give satisfaction compared with the other sorts. The remarkably few small leaves rather detract from its value, for they break in pulling the radish unless it be in very loose soil. It is certainly no radish for the field, and is the smallest in size of the whole list.

Radishes.

Station number.		Seeds from.	First marketable.	Days from sowing.	Last marketable.	Weight of aver. root in grams.	Shot to seed.
1468	Bl'dale Long Scarlet Strap-leaved,	Landr.,	June 10,	39	June 22,	10	June 14
1473	Chartiers,	"	" 11,	40	" 22,	23	" 18
1581	Chartiers Improved,	Ferry,	" 10	39	" 26,	12.5	" 20
1477	China Rose Winter,	Landr.,	" 20,	49	July 2,	75	" 22
1459	Deep Scarlet Turnip,	"	" 4,	33	" 6,	12	" 26
1453	Derp Scarlet Olive-shaped,	"	" 6,	35	" 4,	10	" 28
1456	Erfurt Turnip,	"	" 6,	35	June 28,	8	" 23
1461	Early Garnet	"	" 8,	37	" 24,	8	" 18
1466	Early White Turnip rooted,	"	" 10,	39	July 4,	10 5	" 25
1462	French Breakfast,	"	" 6,	35	" 6,	9	" 26
1474	Golden Globe,	"	" 11,	40	June 25,	24	June 18
1465	Landreth's White Lady Finger,	"	" 11,	40	" 27,	12	" 22
1469	Long Scarlet Short Top (American seed),	"	" 13,	42	July 2,	11	" 22
1470	Long Scarlet Short Top (Foreign seed),	"	" 11,	40	June 29,	19	" 22
1471	Long White Vienna,	"	" 14,	43	July 6,	7	" 26
1479	Long White Spanish,	"	" 28,	57	" 6,	34	" 6
1481	Long White Red Crown,	"	" 19,	48	June 24,	42	" 20
1467	M. G. Early Long Scarlet,	"	" 10,	39	July 6,	15	" 25
1599	Ne Plus Ultra Scarlet Turnip,	Ferry,	" 13,	42	June 24,	5 5	July 2
1458	Prussian Globe,	Landr.,	" 7,	38	July 4,	7	June 29
1532	Philadelphia White Box,	Vick,	" 6,	35	June 22,	20.5	" 13
1460	Red Turnip Rooted,	Landr.,	" 6,	35	July 4,	12	" 29
1478	Russian Long White,	"	Oct. 6,	157	...	178	....
1460	Round Black Spanish,	"	" 6,	157	.	230	.
1547	Raphanus Caudatus (edible pods),	Thorb.,	June 20,	49	July 22	. . .	June 13
1455	Short Top White Turnip,	Landr.,	" 6,	35	June 30,	9	" 25
1472	Summer White,	"	" 10,	39	" 23,	13 5	" 8
1475	Scarlet China Winter,	"	" 22,	51	July 2,	60	" 22
1476	Stuttgart Round White,	"	" 24,	53	" 12,	81	" 26
1457	White Tipped Turnip,	"	" 6,	35	" 2,	8.5	" 25
1464	White Olive Shaped,	"	" 6,	35	" 2,	11	" 26

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TOMATOES.

About thirty varieties of tomatoes were tested side by side, including many of the old standard varieties and several "novelties," which have proven satisfactory in some particulars.

The seeds were sown in shallow seed boxes on March 19, and kept in the greenhouse, where they vegetated in ten days. Four varieties, Early Advance, Boston Market, Beauty and Reed's Island Beauty received from the United States Department of Agriculture, some days later, were not sown until April 10, which accounts somewhat for the later ripening of the fruit and comparatively smaller product of these varieties. When the seedling plants were large enough they were transplanted to a warm hot bed, with a rather heavy soil, which, with careful ventilation, gave us fine stout plants. Of these, the ten best plants of each variety were selected to set out in the garden, which was done on June 2. Many of them were in bud, but showed scarcely any check by the transplanting. There is nothing gained by setting out tomatoes much before the first of June, as the temperature of the garden soil in May is generally so much below that of the beds in which the plants have been growing. In the following table is given the time of appearance of the first flower and of the first ripe fruit, and in the next column is given the number of days from the time of transplanting to the garden to that of the ripening of fruit. These figures are a better test of the earliness of a variety than those counting from the time of sowing of the seed, since such various conditions affect the plants previous to being planted in the field.

The yield of the plants was obtained by weighing all the fruit as it ripened on three best plants from each variety, until they were killed by frost. The green fruit remaining at that time was not taken into account. The weight of single fruits will serve to indicate the size of the berries. The greatest yield of all the varieties tested was from the old Trophy, but it cannot be recommended for smoothness. A cross section of the fruit shows a predominance in solid flesh over seed spaces. The Livingston tomatoes found in the table have pretty fruits, round, smooth and almost invariable in these characters. Such a tomato would give more satisfaction than one that has a tendency to cripple even though the product be greater.

Of the new varieties found in the table we can say the *Golden Queen* is all that is claimed for it, being a good, smooth, yellow tomato resembling the Paragon in size and form, although the figures in the table show a greater size and yield of fruit. *Ring-leader* is indeed a large tomato, much lobed, but quite solid with flesh. *Volunteer* is about the size of Paragon, but almost as round as a ball, bright red, with thick fleshy walls, quite early and productive. *Mikado* is a large tomato with a good yield, fruit somewhat uneven at the apex, the foliage is very distinct, being a darker green than the

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ordinary and having fewer and broader leaflets. *Optimus* is a good smooth tomato, dark red, and solid flesh, ripens early. *Dwarf Champion* is a very distinct variety, dwarf and stout in growth; holds the fruit from the ground. Fruit is good, smooth, dark red, solid flesh, early and fairly productive.

Tomatoes.

Station number.		Seeds from.	First flower.	First fruit ripe.	Days from planting.	Average yield per plant in grams.	Weight of a fair fruit in grams.
1493	Acme.	Landreth,	June 9,	Aug. 23,	82	3318	278
1498	Bermuda.	Landreth,	" 7,	" 9,	66	3215	78
1726	Boston Market,	U. S. Dep't. Agr.	July 15,	Sept. 8,	98	1903	160
1728	Beauty.	U. S. Dept. Agr.	" 18,	Aug. 28,	87	1624	295
1591	Dwarf Champion,	Vick.	June 12,	" 8,	67	2801	173
1490	Early Jersey,	Landreth,	" 9,	" 25,	84	2832	203
1725	Early Advance.	U. S. Dept. Agr.	July 13,	" 29,	88	1751	135
1411	Extra Early or Cluster,	Landreth,	June 6,	" 6,	63	4929	178
1492	Extra Early Richmond,	"	" 7,	" 7,	66	4184	174
1508	Feejee Improved,	"	" 18,	" 29,	88	3438	221
1494	Gen ral Grant,	"	" 5,	July 24,	52	2848	109
1401	Golden Trophy,	"	" 12,	Aug. 16,	75	5111	178
1581	Golden Queen.	Dreer,	" 11,	" 14,	78	3597	206
1506	Grape or Cherry,	Landreth,	" 2,	" 9,	68	. . . . .	1
1584	Ground Cherry or Husk,	Ferry,	" 1,	" 16,	75	. . . . .	2
1502	Ivory Ball or Green Gage,	Landreth,	" 9,	" 4,	68	2770	42
1496	Livingstone's Beauty,	"	" 9,	" 24,	83	4265	217
1495	Livingstone's Favorite,	"	" 9,	" 28,	87	3201	309
1500	Livingstone's Perfection,	"	" 9,	" 23,	82	2866	232
1589	Mikado.	Thorburn,	" 5,	" 18,	77	4999	278
1581	Optimus,	Ferry,	" 9,	" 1,	60	2836	145
1499	Paragon,	Landreth,	" 12,	" 8,	67	1748	178
1501	Peach,	"	" 13,	" 9,	68	1850	88
1585	Ring-leader.	Dreer,	" 12,	Sept. 1,	91	3876	470
1727	Reed's Island Beauty,	U. S Dept. Agr.	July 13,	Aug. 28,	87	3159	360
1497	Trophy,	Landreth,	June 9,	" 23,	82	6135	315
1588	Volunteer,	Thorburn,	" 7,	" 9,	68	5937	191
1583	White Apple,	Ferry,	" 9,	" 16,	75	2516	44
1583	Yellow Plum,	"	" 9,	" 8,	61	2623	33

WEEDS.

About one hundred feet north of the garden, a plot of ground one-twentieth of an acre in extent, that had been used for agricultural experiments previously and is known to the Agriculturist as Plot B, was plowed in the fall of 1887 and harrowed in the latter part of April of 1888, and then left undisturbed to note the character of weeds appearing on it during the year. Those springing up in the early part of the season checked the growth of many that would have appeared later in large numbers if the ground had been cleared. The list of weeds given in the table shows very prominently the fact that the bulk of our worst weeds are introduced from some other country. There are other weeds on the farm and they will be reported in a future bulletin. The arrangement in the following list is in accordance to the predominance of one weed over the next in the list, as found on this plot. A very different arrangement would be necessary to indicate the degree of injury each weed exerts on a crop. Weeds are an enemy to every owner of property, and to fight them successfully we should know the habits of the enemy. The botanical name is given with

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each weed, since common names are frequently local names and may vary in different parts of the State. Different weeds often have the same common name and therefore confusion frequently results when such names are depended upon. In order that these weeds may be recognized by those persons not familiar with the names, short descriptions will be found in this report.

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Growth of Weeds on Plot B.

Common Name.	Botanical Name.	Longevity.	Native or introduced.	Date of first flower.	Height of plant in inches.	Date of ripe seed.
1. Rag Weed or Bitter Weed,	Ambrosa artemisiæfolia,	*a*,	Native,	July 31,	30	September 6
2. Field or Sheep Sorrel,	Rumex acetosella,	*p*,	From Europe,	May 31,	14	July 24
3. Foxtail Grass,	Setaria glauca,	*a*,	" "	July 20,	22	August 10
4. Pennyroyal,	Hedeoma pulegioides,	*a*,	Native,	" 21,	10	" 4
5. Black Bindweed,	Polygonum convolvulus,	*a*,	From Europe,	June 22,	20	" 8
6. Common Plantain,	Plantago major,	*p*,	" "	July 23,	6	" 3
7. Common Smartweed,	Polygonum Hydropiper,	*a*,	" "	" 14,	18	" 10
8. Spotted Spurge,	Euphorbia hypericifolia,	*a*,	Native,	" 15,	6	" 6
9. Lamb's Quarters,	Chenopodium album,	*a*,	From Europe,	" 2,	15	" 5
10. Shepherd's Purse,	Capsella bursa-pastoris,	*a*,	" "	May 27,	24	July 15
11. Door Weed or Knotgrass,	Polygonum aviculare,	*a*,	" "	July 20,	18	August 2
12. Purslane Speedwell,	Veronica peregrina,	*a*, *b*,	Native (?),	May 30,	6	July 5
13. Green Foxtail Grass,	Setaria viridis,	*a*,	From Europe,	July 12,	17	August 6
14. Horse Weed,	Erigeron canadense,	*a*,	Native,	August 15,	15	September 8
15. White Clover,	Trifolium repens,	*p*,	From North,	July 24,	4	August 10
16. Kentucky Blue Grass,	Poa pratensis,	*p*,	Native,	June 6,	16	July 20
17. Red Clover,	Trifolium pratense,	*p*,	From Europe,	" 20,	16	" 18
18. Timothy,	Phleum pratense,	*p*,	" "	" 30,	24	" 25
19. Yarrow or Milfoil,	Achillea millefolium,	*p*,	" "	September 28,	20	October 10
20. Sow Thistle,	Sonchus oleraceus,	*a*,	" "	July 10,	18	July 22
21. Butter-and-Eggs,	Linaria vulgaris,	*p*,	" "	August 4,	8	August 30
22. Dodder,	Cuscuta Gronovii,	*a*,	Native,	July 20,	48	" 10

a.—Annual. *b*.—Bi-ennial. *p*.—Perennial.

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Weeds are most easily destroyed by cultivation in a dry time, and the same operation is beneficial to the crop thus cultivated. Annuals should be killed before maturing their seed. Perennials spreading by root or underground stem can best be destroyed by depriving them of their leaves during their growing season, as no plant can live without these important organs for any great length of time. Never leave land lying idle to grow up in weeds

1. *Ambrosia artemisiæfolia* (ragweed, bitterweed, hogweed, Roman wormwood).

A very common annual in cultivated ground; two to three feet high, much branched. The leaves are from one to four inches long, alternate on the stem and divided into narrow lobes. The flowers not showy, borne on the ends of the branches and are of two kinds, male and female, making the plant monœcious. The male flowers are in drooping heads arranged along an upright raceme one to three inches long. At the base of the racemes are clustered the female flowers, fewer in number and erect in the axils of bracts. This weed is found in all cornfields, and may spring up and seed after cultivation has ceased.

2. *Rumex acetosella* (field sorrel, sheep sorrel).

This little perennial is a native of Europe, but has settled itself so comfortably in this country that it seems to be a native here. An examination of its flowers and seeds will show a resemblance to the buckwheat and docks, all of which are found in the same family or order of plants. The plant spreads by underground runners, which send up stems six to fifteen inches high, bearing a few alternate thickish leaves, hastate or arrow-shaped with the lobes at the base spreading. The flowers are not showy, arranged in a raceme, or compound raceme on the top of the erect stems. This plant is said to be *diœcious*, because only male flowers, those having stamens, are found on one plant, and the female flowers, those having a pistil, on a distinct plant. This weed is seen in abundance in sterile land, but that does not prevent its growing in fertile soil. From the latter place it may be crowded out by more vigorous plants.

3. *Setaria glauca* (foxtail, barn, summer or pigeon grass).

A very common annual grass in cultivated ground resembling that plant grown under the name of millet, one to three feet high, forming "stools" when vigorous. The flowers or seeds are found in the tawny, bristled spike two to four inches long at the top of the slender culm. This grass is very prolific in seeds. At the Ohio Experiment Station in 1885 it was determined that on a plant of eighty-two spikes, averaging 238 seeds to the spike, there were over 19,000 seeds.

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4. *Hedeoma pulegioides* (American pennyroyal).

This plant is well-known by its aromatic scent and taste, and is very commonly found in open fields along with sheep sorrel. It grows from five to ten inches high, branching and bearing short-petioled leaves, ovate and green with few flowers clustered in the axils of the leaves along the stem. The corolla is bluish and slightly protruding from the calyx. As a medicinal plant it is extensively used in domestic practice for a variety of complaints.

5. *Polygonum Convolvulus* (black bindweed).

Another plant belonging to the buckwheat family, though twining in habit. One to three feet long, stem smooth with alternate, almost halberd-shaped leaves; flowers small in panicled racemes in the axils of the upper leaves. There is another species of Polygonum resembling this one greatly, but is a perennial instead of an annual, and is commonly called the Climbing False buckwheat.

6. *Plantago major* (common plantain).

A native with perennial root, found in yards as well as fields. The plant has no appreciable stem, all the leaves radical, (or from the root) smooth, broad, ovate with five to seven ribs running from the petiole to the apex. The flowers are on the long erect spikes growing from among the leaves, six to eighteen inches long. These spikes with their ripened seed are given to birds, as they relish the food they yield. The best method of clearing a lawn of this weed is to cut out the plants *below the crown* with a table knife.

7. *Polgonum Hydropiper* (common smartweed).

Another member of the buckwheat family. In habit the plant is erect and branching, one to two feet high with lanceolate leaves one to two inches long, the flowers on nodding spikes at the top of the branches. This weed is readily destroyed along with the other annuals by careful cultivation, not allowing it to seed.

8. *Euphorbia hypericifolia* (spotted spurge.)

This is a low spreading plant, found in cultivated soil very commonly, but cannot be called troublesome. It may be identified by having a milky juice in its tissues. The leaves are alternate, oblong, one-half to one and one-half inches long, often with a red spot in the center. The peculiar flowers are arranged in loose, leafy cymes at the ends of the branches.

9. *Chenopodium album* (Lamb's quarters, pig weed).

This very common weed grows to a height of five feet in a rich soil, while in a poor soil it blossoms and seeds without exceeding

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one or two feet in height. The height given in the above table is low owing to ground being left compact and predominating weeds crowding upon the later ones. The stem is stout and much branched. The leaves, one to three inches in length, and with a white powdery surface are oblong or ovate in form, alternate on the stem. The larger leaves are coarsely toothed on the margin. The flowers of this weed like all those previously described, are without beauty of color; they are small, gathered in roundish clusters arranged along slender spikes that terminate the branches. The young leaves of this weed are sometimes used in the kitchen in the same manner as spinach.

10. *Capsella Bursa-pastoris* (Shepherd's purse).

This weed is common in every garden and along roadsides. The habit is upright, branching, height six to twenty-four inches. The leaves are mostly at the base of the plant and become small toward the flowers. The form of leaf is from three to six inches long, two inches wide and irregularly cut in at the sides, like the leaves of the dandelion. The flowers first appear in a flat head which is soon raised higher leaving the seed pods of the earliest flowers behind. Each flower on a long pedicel is composed of four small white petals arranged in the form of a maltese cross, which gives the name of cruciferae to the family of plants of which this is a member. The seed pod or capsule has a resemblance to a purse as indicated in the specific and common names.

11. *Polygonum aviculare* (knot-grass, goose-grass or door weed).

This weed is found in walks and similar hardened surfaces, with its branches lying prostrate on the ground. It reaches out six to eighteen inches, and its stems are exceedingly tough to a hoe. There is a variety of this plant with erect stem and larger leaves. The leaves of the specimen being described are about a half inch long, alternate, oblong, sessile, with the small greenish white flowers in clusters of three to five in the axils. Another annual of foreign introduction.

12. *Veronica peregrina* (neck weed or purslane-speed well).

A common weed in damp ground, three to six inches high, branching from the base, the leaves oblong and toothed along the margin, almost sessile, opposite on the stem and bearing the inconspicuous whitish flowers in their axils. The pods containing many seeds are notched at the top. It is not a troublesome weed.

13. *Setaria viridis* (green fox-tail grass).

The name will indicate the close relationship of this grass to No. 3, which it resembles in every outward fact except the color of the spike-like inflorescence which is green in this one.

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14. *Erigeron canadense* (horse weed, butter weed).

An annual reaching maturity at various heights from six inches to five feet, according to the location. The stem erect, branching. The laterals not spreading, but rather close to the main stem. The leaves are lance-linear with entire margin except in the lower leaves, sessile, alternate. The flowers terminate the many branches, forming a compound panicle of small heads; each head contains numerous minute florets. Those forming the outer circle of the head have white strap shaped corollas, inconspicuous. This weed is common in pastures and lawns, it can be driven out by not allowing it to ripen seed for a period of three or four years.

15–18 inclusive are well-known fodder plants and need no description here.

19. *Achillea Millifolium* (yarrow, milfoil).

A perennial herb one to three feet high, mostly simple but branching at top, forming flat-topped corymbs of white flowers. Leaves are green and nearly sessile, two to three inches long, exceedingly much cut into narrow toothed segments. Flowers in heads after the manner of the Erigeron. The white strap-shaped corollas broad and from six to ten to each head. The whole plant has a bitter aromatic scent and taste. It is generally found in clumps in pastures or fields and can best be destroyed by digging up with a spade, although in Europe it is regarded of some value in pastures.

20. *Sonchus oleraceus* (common sow thistle).

A member of the large family known as Compositæ, having numerous flowers in a close head, like the dandelion, of which each head is frequently taken as one flower. The plant grows erect, one to five feet high, with a milky stem bearing alternate leaves that are clasping at the base, irregularly pinnatified the divisions tipped with soft spiny teeth. The heads of flowers arranged in a corymb at the top of the plant, the color of the corollas light yellow. The seeds are tipped with white capillary pappus similar to that on lettuce seed. Never allow the plants to blossom to avoid their spreading.

21. *Linaria vulgaris* (butter-and-eggs, toad flax).

This is not a common weed, although is very generally found in bunches, in pasture fields and along roadsides. It is perennial with a creeping root stalk from which rise numerous stems one to three feet high, smooth, bearing very many narrow pointed leaves one to two inches long, of a bluish-green color, and terminated by a spike-like raceme of beautiful yellow flowers. The corolla is one inch long, two lipped in form, spurred at the base.

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22. *Cuscuta Gronovii* (dodder).

This is a leafless herb, consisting of a yellowish threadlike stem with a few minute scales instead of leaves, found twining over various plants like a coarse web. The seeds germinate in the ground, and the plant rising soon becomes entirely parasitic on the herbs on which it twines and from which it sucks nourishment. Flowers are small, white, in clusters soon resulting in the round seed pods swelling over the corolla.

GRAPES.

Cultivation.

On the college grounds is a vineyard of 450 vines, most of which were planted about fifteen years ago. The location is almost level, with our characteristic limestone soil. The vines are trained to trellises running northwest and southeast, in order to be parallel with some established lines. The trellis is made of upright posts at regular intervals and a horizontal rail eighteen inches, and one at four feet from the ground, to these are nailed perpendicular laths six inches apart. The pruning and training has been according to what is known as the Fuller system, but owing to the want of skilful labor previous to last year, the vines are not yet in their best shape. The bearing wood should be equally distributed over the entire surface of the trellis, and from the time this is accomplished, the winter pruning consists simply in cutting back the stout canes to spurs of one sound bud or eye, cutting out entirely the weak and dead wood, and replacing disabled wood. In a moist soil the great tendency of vines is to run into considerable wood, taking strength from the fruit, and shading it from the sun. It is therefore necessary to good results to practice "summer pruning." Not however, by waiting until the latter part of July or August and then slashing right and left with a sickle, when the berries are full grown; but by beginning when the young shoots have grown four or five joints beyond the bunches of young fruit and "pinching" off the heads at about that length, and cutting out entirely weak fruitless sprouts. This pinching should be attended to about once each week through June and July. This system was practiced on our vineyard this year, and an excellent crop of fruit was gathered from the vines; bunches full, heavily shouldered, large and immense berries. One of these fine bunches of Concord weighed slightly over one pound. The body of the bunch held ninety-two berries and the shoulder piece thirty berries, making a total of 122 berries to the bunch. The largest berry weighed 5.72 grammes. Two such bunches were on the one cane. It requires but one season's careful pruning to prove the decided merit of the practice.

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Disease and Remedies.

The attack of fungus diseases upon the grape this year was not as strong as had been observed in former years, and according to reports from various parts of this State, grapes generally gave a good crop. Signs of black-rot and mildew began to appear in the last days of July. A little mildew was found on the leaves also, and it was decided to make some tests of the remedies recommended by the United States Department of Agriculture, as contained in their circular No. 5, dated April 25, 1888.

The liquids were applied with a fountain syringe after each rain for three weeks, and the powders were applied in the mornings when the leaves were moist with dew.

The remedies used were as follows:

1. *Simple Solution of Sulphate of Copper.*—Made by dissolving one pound of pure sulphate of copper in twenty-five gallons of water. Applied with syringe to berries and foliage.
3. *Bordeaux Mixture.*—Made by dissolving sixteen pounds of sulphate of copper in twenty-two gallons of water, and slacking thirty pounds of lime in six gallons of water in another vessel. When the latter mixture has cooled, the two are poured together, carefully mixing them by constant stirring. Applied with syringe.
5. *Eau Celeste, Modified.*—Made by dissolving two pounds of sulphate of copper in two gallons of hot water, and in another vessel dissolving two and one-half pounds of carbonate of soda in two gallons of hot water, the two solutions are then mixed and when chemical action has ceased, one and one-half pints of ammonia are added, and then the mixture is diluted to twenty-two gallons with water.
16. *Sulphur.*—Flowers of sulphur, applied as a powder for mildew on the foliage.

These remedies have been used with good results elsewhere, but we did not have enough of the diseases this year to make a good test of them.

Varieties.

Two year-old vines of the following varieties of grapes were planted in the vineyard in the spring of 1886, for the purpose of testing their merits:

1. *Worden.*—The vines were noted in 1887 as having made very good growth. July 11, 1888, a healthy growth on which was set considerable fruit. The exact date of ripening was not noted, but it was observed in September that the bunches were loose, with defective berries, black, quality extra. Next year should give us a better test of this new variety. In the Chautaqua Vineyard district this variety is placed second only to Concord on the score of general merit. The berries are claimed to be larger than those of Concord and to ripen earlier.

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2. *Brighton.*—The plants made but a slight growth in 1887, bearing no fruit. This year there was a good growth, with some fruit, bunches good, compact, berries resembling Catawba in color, quality good.

3. *Delaware.*—Made a fair but slender growth in 1887. This year it made a good growth with considerable fruit, close bunches and quality extra. The berries are light red in color, the size of Clinton's, but its flavor will recommend it widely. This is not a very recent introduction and is known to stand our winters. The entire plant, its canes, leaves and berries are on a smaller scale than most grapes, even at its best.

4. *Lindley* (Roger's No. 9).—Vines made a vigorous growth last year, yielding a little fruit. This year there was a good, strong growth, with more fruit. The bunches were loose, as generally claimed for this grape, berries round, red, some defective, quality very good.

5. *Salem.*—Evidently a strong grower, by the vigorous shoots of last year and this. Some fruit was produced this year, bunches loose, berries round, red, large and quality good.

6. *Lady.*—A fair growth last year, setting and ripening a little fruit, but no better this year. This is said to be a white seedling of Concord. The berries are about the same size and of a light greenish-yellow color. The quality is extra, though there are better whites.

7. *Pocklington.*—A fair growth last year. This year a good growth with much fruit, bunches small, berries large, light yellow, quality good, with a foxy flavor. By some growers considered first among the whites.

8. *Prentiss.*—Has made only a fair growth as yet, with but little fruit, light greenish-yellow in color.

9. *Niagara.*—This variety has made a good growth each year, yielding considerable fruit this year. The bunches full, compact, berries large, round, greenish yellow, good, with a foxy odor. Likely to prove more satisfactory from older vines.

10. *Duchess.*—The vines made a slight growth last year, with some fruit; a better growth this year, with but a little fruit, which was very good. It is a white grape, of variable size in the berries and it is said easily susceptible to mildew in some localities.

Some additional varieties were added to the vineyard in the spring of this year, namely:

Jefferson.—A red grape, claimed to be a cross between Concord and Iona.

Catawba.—A red vinous grape, late in ripening.

Isabella.—The old vigorous grower, with black berries.

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Wilder (Roger's No. 4).—With large black berries.

Moore's Early—Said to ripen with Hartford Prolific. If the berries stick to the bunches when ripe, it will be a valuable improvement.

ORCHARD FRUITS.

The old orchard on the college grounds contains some 450 trees that were principally planted about 1860, but no record of the early planting can be found. Including some recently planted young trees there are represented about forty varieties of apples in this orchard, besides a few others that have not yet been identified.

In the spring of 1886 a young orchard of pears, plums, quinces and apricots was planted, chiefly for the purpose of testing a number of varieties. These include, among pears, the following: Le Conte, Kieffer, Smith's Hybrid, Suet Tea, Cocklin, Garber, Early Harvest, Bartlett, Beurre Diel, Duchesse d'Angouleme, Lawson, Sha Tea, Mikado, Vicar of Wakefield, Flemish Beauty, Seckel, Louise Bonne de Jersey, Onondaga (Swan's Orange, Beurre d'Anjou, Easter Beurre, Sheldon, Lawrence, Doyenne d'ete.), Howell, Clapp's Favorite, Josephine de Malines, Beurre Clairgeau, White Doyenne, Tyson, Winter Nellis.

Among plums the following varieties: Yellow Gage, Coe's Golden Drop, Lombard, Gen. Hand, Imperial Green Gage, Smith's Orlean's, Bavay's Green Gage, German Prune, Moore's Arctic, Purple Damson, Duane's Purple, Miner, Yellow Egg, Washington, Bradshaw, Bryanstone Gage, Orange, McLaughlin, Goliath, Fellemburg, Pond's Seedling and Wild Goose.

Of quince, the following: Apple or Orange, Champion, Rea's Mammonth, Meech's Prolific and Augurs.

Of apricots: St. Ambrose, Peach, Purple and Breda.

At present this young orchard contains 150 trees. The ground is being cultivated and free from weeds. The Chinese pears have made luxuriant growths, and held their large glossy leaves late into the autumn. The Mikado this year yielded on two trees twenty-two fine-looking fruits of a firm white texture, with a perfect form and an evenly colored yellow skin, but when tested in the latter part of November the fruit was devoid of juice or flavor. A few other varieties of pears ripened a few fruits, but not perfect specimens, except some Kieffers, which were of a medium size and a fair quality.

The plum and quince trees have made excellent growth, the latter giving a few fruits this year on the Champion and Rea's Mammoth that promise good results for the future.

The apricots have lived through the last two winters tolerably well, but have not yet gained much size.

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PHENOLOGICAL OBSERVATIONS.

The influence of climate on vegetation is strikingly illustrated in a record of the dates when the first foliage, flowers and fruits appeared upon plants and trees growing in the same locality. Much vegetative action in the spring is due to heat and moisture only; no nourishment from the soil being needed. A simple and interesting experiment on this point, is the following: a few dormant twigs of flowering wood cut from a bush of Forsythia Viridissima on the 30th of January, were put into a vase that the ends might be kept in water, and the vase thus arranged was placed in a room of about 62° Fahrenheit. In one week's time the buds had pushed out of the enclosing scales and a few days later the twigs were literally a mass of yellow bell-like corollas. The experiment might be tried in December, with equal results, and distilled water may be used if it is thought some nourishment is extracted from ordinary water.

Phenological notes are of service to such persons as are contemplating the planting of ornamental or shade trees; for while a Catalpa, for example, is known to be a rapid grower, has large leaves and makes a healthy shade, yet when it is found, as shown in the notes of the table, that the Catalpa does not come into leaf until the 28th of May, when other trees have long been affording a heavy shade, we then have a serious objection to planting such a tree for such a purpose.

Such observations are of great service to the forester, also, particularly if they are taken at numerous points over the country, in order to note the capacity of a species for acclimatization.

The following tables are not complete, but will indicate the character of the notes to be taken and many persons interested in vegetation in any form will find such observations, taken in their own localities, of considerable value.

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Trees.

Common Name.	Botanical Name.	First leaf.	First flower.	Ripe fruit.	Complete change of foliage.	Native or cultivated.
American Ash,	Fraxinus Americana,	V, 8	V, 4			Native.
Apple,	Pyrus Malus,	V, 2	V, 8			Cult.
Austrian Pine,	Pinus Austriaca,	VI, 15	VI, 7			"
American Elm,	Ulmus Americana,	V, 12	V, 1		X, 2	Native.
Box Elder,	Negundo aceroides,	V, 4	IV, 30		IX, 28	Cult.
Birch,	Betula alba var. Populifolia,	IV, 28	IV, 30		IX, 30	"
Beech, Purple,	Fagus sylvatica,	V, 4				"
Cherry,	Cerasus,	V, 4	IV, 30	VI, 18		"
Cherry, Choke,	Cerasus Virginiana,	V, 6				Native.
Catalpa,	Catalpa Speciosa,	V, 28	VI, 20	X, 1	X, 8	Cult.
Cucumber Tree,	Magnolia Acuminata,	V, 11	V, 25		X, 2	"
Honey Locust,	Gleditchia triacanthos,	V, 22	VI, 14		X, 8	"
Horse Chestnut,	Aesculus Hippocastanum,	IV, 30	V, 19		X, 11	"
Kentucky Coffee Tree,	Gymnocladus Canadensis,	V, 28				"
Larch, European,	Larix Europea,	IV, 30	V, 3		X, 10	"
Linden, American,	Tilia Americana,	V, 21	VI, 5		X, 2	"
Locust Tree,	Robinia pseudacacia,	V, 25	VI, 5			"
Maple, Norway,	Acer pseudoplatanus,	V, 1	V, 5	IX, 26	X, 6	"
" Red,	" rubrum,	V, 5	IV, 1		X, 10	Native.
" Silver,	" dasycarpum,	V, 1	IV, 1	VI, 5	X, 6	Cult.
Norway Spruce	Abies excelsa,	V, 11				"
Peach,	Prunus Persica,	V, 10	V, 3			"
Pear,	Pyrus communis,	V, 7	V, 7		X, 6	"
Walnut, Black,	Juglans nigra,	V, 8	V, 31			Native.

Shrubs.

Common Name.	Botanical Name.	First leaf.	First flower.	Ripe fruit.	Native or cultivated.
urning Bush,	Euonymus atropurpureus,	IV, 28	VI, 10		Cultivated.
Currant,	Ribes rubrum,	V, 8	V, 12		"
lder,	Sambucus Canadensis,	V, 2	VI, 20		Native.
Forsythia,	Forsythia viridissima,	V, 6	IV, 27		Cultivated.
Honeysuckle, Upright,	Lonicera Tartarica,	IV, 26	V, 15		"
" Vine,	" Halleana,	IV, 28	VI, 18		"
apan Quince,	Cydonia Japonica,	IV, 23	V, 8		"
udas Tree,	Cercis Siliquastrum,	V, 22	V, 10		"
Mahonia,	Berberis aquifolium,	V, 18	V, 8		"
Mock Orange,	Philadelphus coronarius,	V, 7	VI, 10		"
Privet,	Ligustrum vulgare,	V, 4	VI, 15		"
Purple Fringe,	Rhus Cotinus,	V, 16			"
hadbush,	Amelanchier Canadensis,	V, 6	V, 2		Native.
Silverbill,	Halesia tetraptera,	V, 10	V, 14		Cultivated.
weet Briar,	Rosa rubiginosa,	V, 4	VI, 18		Native.
assafras,	Sassafras officinale,	V, 12	V, 8		"

Herbs.

Common Name.	Botanical Name.	First leaf.	First flower.	Ripe fruit.	Native or cultivated.
Chickweed,	Stellaria media,		IV, 28	V, 3	Native.
Bloodroot,	Sanguinaria Canadensis,	IV, 24	IV, 20	VI, 25	"
Crocus,	Crocus luteus,	IV, 9	IV, 1		Cultivated.
Dandelion,	Taraxacum densleonis,		IV, 23	V, 20	Native.
Liverleaf,	Hepatica triloba,		IV, 17		"
Narcissus,	Narcissus Pseudo Narcissus,	III, 28	IV, 22		Cultivated.
Tulip,	Tulipa Gesneriana,	III, 28	IV, 30		"
Trailing Arbutus,	Epigea repens,		IV, 7		Native.
Thalictrum,	Thalictrum anemonoides,	IV, 26	IV, 28		"
Shepherd's Purse,	Capsella bursa-pastoris,		IV, 25	VI, 10	"
Strawberry,	Fragaria Virginiana,		V, 8	VI, 15	"
White Violet,	Viola blanda,		IV, 20		"

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AN EXPERIMENT IN FORESTRY

BY WM. H. BUCKHOUT.

There are but few subjects which have been written upon and discussed more frequently in the agricultural journals in recent years than that of forestry. The need of paying more attention to the renovation of our forests by the planting of trees or the protection of new growth has been very fully and ably set forth in these journals, and in the discussions at farmers' gatherings. It has been shown that our forests are disappearing, and that their natural replacement is slow and imperfect. So marked is this in the older parts of the country that timber and lumber of all kinds are drawn from remote districts, and it has become a serious question where the future supply is to come from. Moreover, various incidental benefits, climatic and sanitary, are claimed with apparent good reasons to be due to our wooded acres. So far, however, the discussion of forestry matters has not resulted in much practical work. Few persons are willing to expend time and money and land in tree-raising on a large scale without some better guarantee of the success and value of the undertaking than we now possess. Enthusiasts may urge the need and value of it, may point to the care and attention to such matters in other countries and the great benefit that will accrue climatically from having a certain proportion of our land wooded, but the practical man will still hold back. He must be more certain of the money value of the enterprise; and further it is to many people an entirely novel idea, of the practicability of which they may well have serious doubts. Few enterprises require so long time and are attended by so much risk; and there are few concerning the actual details of which so little is definitely known, since we have had no forest practice worthy the name in this country.

It has seemed natural, therefore, that our experiment stations should endeavor to lead the way in some line or part of forest experimentation, according to the facilities which they severally possess. Pennsylvania has been one of the well-wooded States; moreover, she still furnishes large quantities of wood materials, and has large areas which support forest growth. The forests are gradually disappearing, and in large part the land which they occupied is fit for nothing except a new tree growth. Natural replacement is often unsatisfactory in that the varieties of trees which appear spontaneously are not the best, their growth is not uniform and there is great difficulty in protecting them. Nevertheless, it is the only kind of reforesting that is

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now going on, and it even receives no help and but scant encouragement.

It has seemed to the writer that one of the most instructive things for our Station to undertake would be the study of the forest problem as it is presented to us in our own vicinity, which is a good type of the whole mountainous part of the State. The practical difficulties connected with this problem are neither few nor small. Our mountain lands are rough and rocky, with soil so thin that it seems doubtful whether they can be made to support a tree growth, and yet, for the most part, they have done so in time gone by. This stony soil, mixed with the matted, woody roots of various shrubs, cannot be treated in any ordinary way, and tree planting here is totally unlike that upon arable land. Especially does it require slow and patient labor; that kind of labor which is very hard to get, since most men would like to see immediate results from their work and do not take easily to anything out of the ordinary course. At best the labor required is such that an important object in any experimenting should be to show the cheapest and easiest method of reforesting. With this in view we have secured the use of a small piece of land on the southeast side of Tussey Mountain, which is a fair average of mountain land, and is just such as must be used if in the future there should be any extensive forest planting over our mountainous districts. Cut over some forty years ago for charcoal it had since grown up to a mixed growth of chestnut, pitch pine and various shrubby species, all of which had been subject to periodical fires, so that the growth was thin and unequal. No preparation was given except to cut off and burn all the brush. Had we not been hurried because of the lateness of the season it would probably have been better to have burned over the whole surface so as to have killed the smaller shrubs and have burnt out some of the roots, for one of the chief difficulties in planting was the densely interwoven roots encountered in many places, which not only made it difficult to set the trees properly, but quite slow and tedious work.

The trees planted were chestnut and white pine, the former being about six to eight inches high with very prominent tap roots, and the latter rather larger, averaging ten inches, and trees which had been once transplanted. They were set about five feet apart by digging small holes with a mattock, and no extra pains was taken with them. This place was selected in part because it seemed specially protected from fire, having a small stream upon one side, a spring which feeds a rill upon another, and a spring and rill on part of a third side. With care in burning around the patch each spring for a few years we hope to keep out the fire. Besides the danger from fire another drawback to the success of our project is found in the young cattle which are driven each year to find pasture among the mountains. We are obliged to keep them out by a fence. On a very small scale

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we have tried seed-sowing. Selecting a place which had recently been burned over, we have sowed broadcast a small quantity of white pine, white birch and locust seeds making no effort to prepare the ground or to cover and protect the seed, but trusted to the germination of some which may find suitable conditions in the interstices here and there. However, unpromising this method may seem to be, we were induced to give it some trial, since if it should prove but partially successful it would very materially reduce the cost in reforesting which seems likely to be the one objection most difficult to meet. The seeds chosen are fair types of the lighter, middle weight and heavier tree seeds, and in a state of nature frequently spring up spontaneously even in such abundance as to make a compact forest covering.

By way of making a more careful comparison we have duplicated this work on the College farm where we have a cultivated soil quite different in its character and surroundings from that before mentioned.

This, at present writing, is the extent of our work. It was our intention to have prepared some additional ground during the fall and planted thereon seeds of chestnut and white pine so that we could compare the growth direct from seed with the seedling trees. But the difficulty of getting labor, with the pressure of other duties, has made it necessary to defer it until spring.

It is obvious that whatever of value such experiments as these may have can appear only after some years have elapsed, and that trees of size suitable for any manufacturing purposes can not be had short of a score of years. But although no practical return may ever be derived from this particular piece of work, we hope by care and watchfulness to be able to maintain it at least long enough to reach some definite conclusion regarding the practicability of artificial reforesting, and the best way of doing it, should it prove to be practicable. We have reason to believe that as the forestry problem is one which must be studied largely on the forest lands themselves, we shall thus have all the phases of it so persistently presented to us that we shall not err in our judgment because of inexperience or failure to appreciate what are the real factors in the case. Between the negligent inactive policy regarding mountain lands which now seems to prevail, and the contempt with which they are regarded when once they have been stripped—between this and the roseate views of enthusiasts, who can not see the practical difficulties in the way—there would seem to be some middle course worth seeking for.

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RELATION OF METEOROLOGICAL CONDITIONS TO THE DEVELOPMENT OF CORN.

WM. FREAR AND WM. H. CALDWELL.

The predominant natural influence affecting the growth of a crop in any locality is that of climate. This is far more influential than fertility of soil, though there is a certain minimum of that essential to plant life; but it is a matter of common observation that with exceptionally favorable climatic conditions fine crops may be grown on comparately infertile soils. Each plant has its own most favorable climate. It is a marked property of cultivated plants, as compared with the wild species or varieties, that they may be grown successfully under ranges of climatic condition wider than those well adapted to the original, uncultivated species. But a change of climatic surrounding is generally accompanied by a variation in proportional development of the plant.

The maize plant, with its wide range of territory, has a corresponding range of variation in its variety types; from the tall, large-eared, but very leafy Dents of the south to the low, small-eared, but abundant grain producing Flints of the north. Notwithstanding this exceptional power of adaption to surrounding conditions, the maize crop is as much influenced in development by the seasonal variations as any crop we cultivate. In other words, the conditions favorable to the best development are fixed within a narrow range for any varieties adapted by long culture to the general climate of a given locality. It is a well-known fact, that with all its adaptability, corn cannot be brought to maturity in England with the cool, moist, cloudy summers prevalent there, and it is believed that the heat of American summers, even in the higher latitudes, is the special climatic feature that makes the culture of this valuable plant possible over so extended an area, reaching from Central America to Canada.

As was stated last year, the knowledge we possess concerning the effects of the several elements which unite to form our climate, lacks definiteness, and the results of a series of observations upon the rate of growth of corn were compared with the meteorological observations carried on at the same time, with the hope that careful comparison might bring out into greater prominence those elements producing the most favorable influence upon our varieties of that crop.

This year the observations were continued, the seed being an acclimated yellow dent, and the same method of measurement being followed. Six plants were selected and the increase in height noted at intervals of several days. For this purpose, the tip of each new pair of leaves was used as the point of departure for the days immediately succeeding its appearance. From the figures obtained, an average was

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struck, which was assumed to represent the actual growth for the interval, and by dividing by the number of days intervening, the daily rate of growth was obtained. It was hoped that in this manner errors in measurement, arising from the appearance of new modes of growth, would be distributed over the different plants and thus eliminated. This method cannot take into account the variation in the rate of growth due to climatic changes as distinguished from those due to the development of the special organs of the plant (at ears and tassel), nor to the less noticeable, but no less present, difference in the rate of growth caused by a difference in the stage of maturity; it assumes also that increase in material in the plant, which is doubtless the best measure of its growth, is accompanied by a proportional development of plant organs. All that is claimed for it is, that it serves quite well for comparative purposes, even though it does not give results that are absolutely correct.

The following remarks, upon the development of the plants, will be of interest: May 8, six hills of corn, one and one-half feet apart, three kernels to the hill, were planted in the garden, and covered to a depth of one and one-half inches. The spot was slightly shaded in the P. M. The corn was up in all the hills on May 22. From this day to June 18, the number of plants having been reduced to one in each hill, measurements were taken, but from mistake by the wrong method; on June 18, when the plants were 8x12 inches high, the method above mentioned was returned to, and measurements were continued until August 22, although no increase in height was noted after the 8th. The plants were cultivated last on July 23. One tasseled on July 13, two more on 19th, two more on 23d, and the last on July 31, by which time ears showed on the three that tasseled first. The position for growth was not quite so favorable as in 1887, though there was no difference between the six hills in this respect.

In the following table will be found a statement of the mean intervals of growth of the six stalks:

June	19,	1.6 inches.	July	8,	2 inches.	July	27,	4.3 inches.
	20,	1.6 "		9,	2.3 "		28,	2.9 "
	21,	1.5 "		10,	1.9 "		29,	1.6 "
	22,	1.9 "		11,	3 "		30,	2 "
	23,	1.9 "		12,	2.3 "		31,	1.7 "
	24,	2 5 "		13,	1.5 "	Aug.	1,	1.9 "
	25,	2.9 "		14,	1.5 "		2,	1 "
	26,	2.4 "		15,	2.1 "		3,	1.2 "
	27,	1.9 "		16,	2 "		4,	0.9 "
	28,	1.3 "		17,	2.5 "		5,	0.6 "
	29,	1.1 "		18,	2 "		6,	0.1 "
	30,	1.5 "		19,	2.6 "		7,	0 "
July	1,	2.3 "		20,	2 "		8,	0.2 "
	2,	1.6 "		21,	2.7 "		9,	0 "
	3,	2.3 "		22,	3.6 "		10,	0 "
	4,	2.7 "		23,	4 1 "		11,	0 "
	5,	3 "		24,	4.7 "		12,	0 "
	6,	2.3 "		25,	3.1 "			
	7,	2.7 "		26,	3.5 "			

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In order to show more clearly any relations existing between the observed rate of development and the meteorological conditions, there have been plotted upon the following chart:

Variation of the Growth of Corn and Principal Meteorological Conditions for 1888.

1st, the mean daily rate of growth.
2d, the mean daily atmospheric temperature.
3d, the mean daily soil temperature at three inch depth.
4th, the mean daily humidity.
5th, the mean daily rate of evaporation.
6th, the daily rainfall.

These data are represented by broken lines; to eliminate minor disturbing variations, curves have been drawn representing overlapping averages of these data for periods of five days, so selected that the fourth and fifth days of any period were the first and second of the period next succeeding; the averages thus obtained were placed on the chart opposite the third day of each of these periods, and the curves drawn through the point thus located.

A study of these curves in 1887 showed that the temperature was the controlling element among the meteorological conditions of that year. The corn was planted May 12, and reached its average maximum height of 80 inches, by July 23, a period of seventy-two days, during which there was a mean daily temperature of 70°, a precipitation of 8.3 inches, thirty-one days on which more than .01 inch of rain fell, and a mean daily cloudiness of 4.2 on a scale of 10.

In 1888 the corn was planted May 8, and attained its average maximum height of 81 inches on August 8, an interval of ninety-two days, during which there was a mean daily temperature of 67°, a precipitation of 11.5 inches, falling on twenty-eight days, of which thirteen occurred before June 1, and a mean daily cloudiness of 4.9 on a scale of 10. Under these conditions the influence of variations in the temperature seem predominant, in such a degree, indeed, that variation in the other conditions within their observed ranges, were productive of no measurable influence upon the rate of growth. Unless it be that the rain-falls of June 21 and 23, and that of July 20, may account for the slight increase in the rate of growth, as compared with that which would theoretically have obtained had the line of increase followed the lines of variation in atmospheric and soil temperature as closely as usual.

Prof. C. S. Plumb made certain somewhat similar observations during 1886, at the New York Agricultural Experiment Station, the result of which he has just recently published.* Beginning with May 21, the date of planting, the last seven plants completed its

*Agricultural Science, Vol. III, p. 1.

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growth in height by August 1, but the principal growth was complete by July 25th, a period of sixty-five days, during which there was an average are temperature of 59°, an average soil temperature at 2 P.M., and at three inch depth, of 72°, a rain-fall of 7.53 inches, and a sunshine of about 6.5 hours average daily duration. The soil was quite uniform, unmanured, fairly moist, and kept fairly free from weeds by hand cultivation. His results did not show the same close correspondence between temperature variation and rate of growth, but here too the principal factor in production of variation, leaving out of account the effect of the development of special organs at the proper stage of growth, seemed to be temperature, with probably a somewhat large influence, due to rainfall. It is difficult, owing to a difference in the method of measurement, to make any close comparison of Professor Plumb's results with those obtained by the method employed at this station. The results were cited rather for the sake of a comparison of final measurements and average climatic condition.

In the prosecution of this work all the care of detailed observation devolved upon Mr. William H. Caldwell, while the planning of the work and comparison of results has been performed by the writer.

METEOROLOGY.

WILLIAM FREAR.

It is universally known that the climatic relations of any locality or season determine chiefly the success in culture of the crops raised, but very little is known concerning the exact relations of climatic differences between several locations or seasons to the success or failure of any given crop, except in the most general way. It is very desirable, therefore, to fix accurately the climatic conditions under which field investigations are carried on, and to determine, if possible, to what extent and in what way a given change in any of the conditions that go to make up weather, affects the various plants submitted to test.

The work of the past year has been chiefly a continuation of the work of the preceding years, including observations of the kind usually made by the U. S. Signal Service upon atmospheric phenomena, and also observations upon soil temperature at various depths, upon the amount of sunshine, and the soil moisture.

The results of the observations upon atmospheric phenomena have been reported regularly to the Chief Signal Officer, U. S. A., and to

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the State weather service, and weekly crop reports have also been sent to the State service.

ATMOSPHERIC METEOROLOGY.

The latitude of the Station is about 40° 55′, and the longitude about 77° 51′. The altitude of the superintendent's house, where the meteorological instruments were placed, is about 1,185 feet above sea-level, the elevation of the barometer's mercury level being 1,191 feet.

The apparatus used consists of a standard mercurial barometer, reading to $\frac{1}{100}$ inch; dry and wet-bulb, and maximum and minimum thermometers by Green, in addition to a standard three-inch rain-gauge and an anemometer.

The thermometer shelter was placed against the north east end of the house, at a height of about twenty-five feet from the ground.

The observations up to June 1, were in immediate charge of Mr. H. J. Patterson, now chemist in the Maryland Agricultural Experiment Station; after that date they were made by Miss Blanche Patterson.

In the following table is presented a summary of the observations for the past year. The observations in full will be found in the appendix.

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Meteorological Summary for 1888. Monthly Means, Etc.

	January.	February.	March.	April.	May.	June.
Atmospheric Pressure, in Inches.						
Monthly mean,	30.248	30.161	30 134	30.154	29 982	29.964
Highest,	30.379	30 972	30 537	30 597	30.325	30.320
Date,	12th 7 A M.	15th, 9 P M.	25th, 7 A M	25th, 7 A M.	7th, 7 A M.	29th, 9 P. M
Lowest,	29.701	29.575	29.365	29 558	29 667	29.683
Date,	1st 2 P M	25th, 2 P M	21st, 7 A M.	2d, 7 A. M	31st 2 P. M.	21st, 2 P. M.
Monthly Range,	1.178	1.397	1.172	1.039	718	.337
Temperature, in Degrees, F.						
Monthly mean,	21 10	23.5	30 5	46.89	57 57	68 80
Maximum,	47.00	56	58	83 5	82	95
Date,	7th	14th	30th & 31st	27th	28th	21st
Mean maximum,	27 9	36.10	38.2	55 98	65 22	78 63
Minimum,	- 9	13	- 1 5	28	30	38 5
Date,	23 1	10	13th	8th	17th	4th
Mean minimum,	10 2	16 62	17 8	33 71	46.63	56.15
Monthly range,	56 00	69	59 5	55 5	58 00	66 5
Daily range—greatest,	27.5	40 5	32 5	37	32 5	35
Date,	23d	15th	19	28th	6th	4
Least,	8	7 5	12	9	7	8
Date,	9th	5	5th, 12th & 15th	14th	11	7th
Mean,	17.7	19 38	20 4	22.27	18 59	22 48
Humidity. Precipitation and Cloudiness.						
Mean relative humidity, per cent,	85 9	84.95	81.4	63 31	73 91	70 64
Mean dew point, degrees, Fahr.,	18 14	23 99	25 44	34 81	34 81	50 33
Precipitation.						
Total, in inches,	3 46	1 70	2 905	2 79	6 26	2.61
Snowfall, in inches,	17 15	4.40	11 5	25	.....	.....
Greatest daily precipitation,	66	.49	82	69	1.21	.78
Number of days on which 01 inches or more of rain fell,	14	9	10	10	17	7
Cloudiness.						
Mean percentage,	7.1	5.7	6 63	31.77	6 3	4 6
Number of days on which cloudiness averaged 80 per cent or more,	15	10	13	6	14	6
Wind.						
Prevailing direction,	W	W, SW	W, NW	W	SE	W
Wind, followed by rain,	W & SW & NW	E & S	E & W	SE & W	S & E	Chiefly W, but E & S on 27th
Wind, followed by fair weather,	W & NW	W & N	W & N	W & N	N & W	W & E
Maximum velocity, in miles,	34 8	18	30	25 9	15 6	15 6
Date,	26th, 2 P. M.	8th & 15th, 2 P. M.	12th, 2 P. M.	11th, 2 P. M.	6th, 2 P. M.	30th, 9 P. M.

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Greatest daily movement, in miles,			28.8		263.4		342.3		348.8		123.7	118.9
Date,			19th		15th		21st		7th		23	11th
Monthly movement, in miles,			2651.4		1547.3		2901.9		2537.8		1247	1246.2
Miscellaneous Data.												
Dates of thunder storms,									5th & 10th		9 h. 10th & 28th	21st
Dates, hail,									7th, 8th & 13th			
" frost,											20th	
" aurora,												3d
" halo, solar,												
" lunar,									22d		21st & 22d	

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Meteorological Summary for 1888. Monthly Means, Etc.—CONTINUED.

	July.	August.	September.	October.	November.	December
Atmospheric Pressure, in Inches.						
Monthly mean,	30 035	30 003	30.088	29 684	30 183	30 111
Highe t,	30 686	30 546	30 509	30 377	30.718	30 646
Date,	17th, 7 A M	11th, 7 A. M	6th, 9 P M	30th, 9 P. M.	18th, 2 P M	30th, 7 A. M.
Lowest,	29 004	29 613	29 715	29 455	29 630	29 548
Date,	18th, 7 A. M.	21st, 2 P. M	16th, 2 P. M	1st, 9 P. M.	10th, 2 P. M.	18th, 7 A M.
Monthly range,	1.681	733	.794	.922	1.088	1.098
Temperature, in Degrees, F.						
Monthly mean,	59.2	69 9	57 71	45.5	41 16	32 20
Maximum,	86	92	77	66	72	48 5
Date,	4th	4th	9th	1st	2d & 6 h	25th & 26th
Mean maximum,	78	78 3	65.18	53 2	48 13	37 71
Minimum,	45	43	32	31	12	1
Date	13th	23d	30th	22d	22d & 23d	22d
Mean minimum,	55 1	56 6	46.33	35.1	20	20.58
Monthly range,	41	49	45	35	60	47 5
Daily ranges–greatest,	31	32	33	29	30	35
Date,	23d & 25th	26th	14th	1st & 31st	1st	24 h & 26th
Least,	8	3	9	6	6	6
Date,	18th	21st	17th	27th	13th	11th
Mean,	22.9	21.7	18 85	18 1	18 13	17 13
Humidity, Precipitation and Cloudiness.						
Mean relative humidity, per cent.,	73.3	73 2	83.3	81.2	77.04	89 49
Mean dew point, degrees, Fahr.,	59.12	61.58	52.90	41 16	40 45	28 80
Precipitation.						
Total, in inches.	2 78	6 16	3 12	3 76	2.71	2.07
Snow fall, in inches,	.....	.....	.....	....	1.08	1 37
Greatest daily precipitation.	92	2.47	1 21	71	74	1 08
Number of days on which .01 inches or more of rain fell,		6	4	13	11	10
Cloudiness.						
Mean percentage,	4.1	4 2	6 4	7.2	5 8	7
Number of days on which cloudiness averaged 80 per cent, or more,	4	3	13	16	14	17
Wind.						
Prevailing direction,	W, E	W	W, N W	W	W	W
Wind followed by rain,	N, W & S	W, N, W, S & E	S, E & W	W & E	E & W	W
Wind followed by fair weather,	W & E	N, N W & E	W	W & N W	W	W
Maximum velocity, in miles,	26.8	8 4	10 8	9 6	8.4	12
Date,	11th	22d, 7 A M.	27th, 2 P. M.	9th, 14th & 19th	4th, 10th & 25th 9 P. M.	14th, 2 P. M.

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Greatest daily movement, in miles,		111.7	125.4	198	241.4	272.4
Date,		22d	16th	9th	25	16th
Monthly movement, in miles,	972.4	807.6	639	1219.9	1668.8	2291.6
Miscellaneous Dates.						
Dates of thunder storms,	19th	13			5th & 21st	30th
Dates, hail,			13, 29			
" frost,						
" aurora,						
" halos, solar,						
" " lunar,		14th & 16th				

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SUNSHINE RECORDS.

The importance of sunshine in plant development needs no comment. The method adopted by the United States Signal Service of recording the per cent. of cloudiness at 7 A. M., 2 P. M. and 9 P. M., affords only a moderate approximation to the real degree of sunshine; therefore, the desirability of determining more closely the amount of sunshine received by the vegetation of this locality. This was done by means of the apparatus described in last year's report, by which the image of the sun as it travels about a spherical reflector, traces a corresponding arc of a circle upon a sensitized paper placed in a camera focused upon the image in the reflector; any break in the sunshine causes a break of similar duration in the photographed path of the sun's image around the sphere. By this method it is possible to get a record only of the duration of sun's length, and not of the relative intensity.

The observations were in the charge of Mr. W. H. Caldwell; the computation from the fixed photographs were made by Miss Blanche Patterson.

The following table shows the daily duration of sunshine from April 4 to November 18, covering the growing period:

Sunshine Records, 1888.

	April.	May.	June.	July.	August.	September.	October.	November.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1,	. . . .	5 49	12 56	10 20	4 0	None.	3 46	6 0
2,	. . . .	None.	3 32	12 3	13 4	12 0	3 46	3 40
3,	. . .	2 33	13 27	13 27	10 2	None.	4 12	1 35
4,	2 0	7 13	10 16	12 8	9 21	None.	3 0	6 0
5,	None.	11 18	13 43	None.	1 4	5 17	3 33	7 0
6,	10 38	11 50	*	9 48	7 2	None.	None	6 20
7,	3 10	11 18	12 43	*	13 50	None.	2 32	4 12
8,	9 37	None.	12 4	5 9	10 53	None.	None.	None.
9,	9 44	2 23	9 54	9 49	12 12	None.	4 12	2 24
10,	None.	None.	5 23	*	13 41	None.	9 21	None.
11,	6 0	None.	12 16	11 20	*	4 0	None.	4 20
12,	8 4	None.	*	None.	6 31	5 44	None.	6 56
13,	11 27	13 49	12 38	10 56	9 8	4 23	None.	7 2
14,	2 0	3 14	8 20	10 16	10 2	12 8	None.	5 52
15,	9 52	6 5	8 51	9 40	9 17	None.	2 44	None.
16,	8 37	6 59	12 0	13 12	11 21	None.	4 21	None.
17,	7 51	12 50	12 16	11 21	None.	None.	8 0	5 22
18,	8 41	2 24	*	8 4	5 33	9 44	6 27	None.
19,	3 51	None.	11 21	None.	*	10 0	5 21	. . . . .
20,	None.	13 7	*	11 2	12 0	None.	4 0	. . . . .
21,	1 52	10 24	8 4	12 56	None.	11 57	None.	. . . . .
22,	10 55	9 23	8 4	11 45	None.	10 27	1 8	. . . . .
23,	4 48	8 16	7 16	12 4	12 4	9 31	None.	. . . .
24,	12 53	None.	8 57	13 4	12 4	2 7	4 56	. . . . .
25,	11 10	8 49	11 16	13 2	11 28	None	4 40	. . . . .
26,	9 33	None.	11 2	9 49	9 41	3 29	None.	. . . . .
27,	9 52	10 33	7 2	6 12	4 4	9 54	None.	. . . . .
28	9 0	8 6	None.	12 4	12 4	7 14	1 53	. . . .
29,	8 0	12 4	None.	12 0	8 59	*	1 7	. . . . .
30	6 50	None.	11 16	9 32	11 6	3 5	3 16	. . . . .
31,	. . . . .	3 13	. .	11 1	None.	. .	5 41	. .
Total,	186 26	181 45	243 42	282 5	240 31	121 0	102 56	66 43
Daily mean,	6 54	5 44	9 22	9 44	8 18	4 10	3 19	3 42

* Record missing.

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SOIL TEMPERATURES.

Observations upon soil temperature have been made in part with the hope of adding something to the knowledge we already possess concerning the climatic conditions of the soil, but more directly for the bearing they have upon the field investigations in progress. These observations are in continuation of those made last year.

The observations were made tri-daily at the same time with the observations upon air temperature. The thermometers were made by Green according to his pattern, and were carefully set in niches cut in a trench, the earth being afterward carefully tamped about the bulb so as to secure a good contact, the trench being filled at the same time. The surrounding surface was freed from vegetation and kept loose by stirring from time to time. The surrounding soil was covered with sod. The depths at which observations were made, were: at the surface, 1, 3, 6, 12 and 24 inches. The soil was a moderately dark, compact, loam for a depth of about seven inches, and after that, a stiff clay subsoil. The rocks, judging from neighboring excavations, were 5 to 7 feet below the surface.

The tri-daily readings will be found in the appendix, but a summary of the more important data is presented in the following table:

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Summary of Soil Temperature—Monthly Mean Temperature.

	April.	May.	June.	July.	August.	September.	October.	November.
	Deg.—Fahr.	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*
Air,	46.89	57.57	68.80	59.2	69.9	57.71	45.5	41.16
Surface,	45.01	55.37	68.31	67.53	67.90	63.71	44.45	46.29
One inch,	43.87	56.46	66.59	65.61	67.41	57.48	44.96	45.75
Three inches,	43.87	55.31	67.95	66.63	67.80	58.12	48.46	46.18
Six inches,	43.54	54.96	65.80	66.53	67.86	59.02	46.18	47.28
Twelve inches,	42.97	53.82	64.27	65.74	67.49	60.06	48.36	48.01
Twenty-four inches,	42.14	51.50	60.89	63.38	65.56	63.62	50.48	48.91

Soil Temperature Summary—Mean Daily Range.

	April.	May.	June.	July.	August.	September.	October.	November.
	Deg.—Fahr.	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*
Air,	22.27	18.59	22.48	22.1	21.7	18.85	18.10	18.1
Surface,	41.98	13.16	17.40	17.59	18.43	14.98	12.55	14.89
One inch,	10.52	7.74	10.72	10.50	10.78	8.91	8.02	11.34
Three inches,	8.19	6.51	8.58	8.19	7.70	6.53	5.33	7.97
Six inches,	4.66	4.03	5.75	5.38	4.17	3.33	2.90	4.41
Twelve inches,	1.37	1.66	2.12	1.50	1.64	.97	.81	1.29
Twenty-four inches,	.43	.70	.69	.24	.31	.31	.34	.52

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Summary of Soil Temperature, 1888.

	April.	May.	June.	July.	August.	September.	October.	November.
	Deg.—Fahr.	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*
ATMOSPHERE.								
Monthly mean, . . .	46.89	57.57	68.83	69.20	69.90	57.71	45.50	41.16
" maximum,	85	82	95	88	92	77	67	72
" minimum,	20	30.50	38.50	45	43	32	14	12
Mean daily range, .	22.27	18.59	22.48	22.90	21.70	18.85	18.10	18.13
Greatest " " .	37	32.50	35	31	32	33	29	30
Least " " .	9	7	8	8	3	9	6	7
SURFACE.								
Monthly mean, . . .	45.01	55.37	68.31	67.53	67.90	63.71	44.45	46.29
Extremes.								
Monthly maximum,	85	81	97	91	95	80	69	71
Date, ...	30,	28,	21,	7,	4,	9,	1,	1
Monthly minimum,	31	36	46	51	54	44	28	26
Date, ...	7,	2,	2,	13,	13,	26,	21,	17
Mean maximum, . .	56.65	63.87	79.10	79.48	79.98	66.55	52.26	54.44
" minimum, . .	38.19	50.87	62.03	61.48	61.59	52.03	36.7	39.94
Range.								
Monthly, ...	54	45	51	40	41	36	41	45
Mean daily, ...	41.98	13.16	17.40	17.59	18.43	14.98	12.55	14.89
Greatest daily, . . .	40	22	27	27	31	24	26	25
Date, ...	28,	3 & 7,	21,	24,	2,	14,	25,	1
Least daily, ...	2	4	6	4	4	3	6	3
Date, ...	5,	25 & 31,	7,	9,	21,	17,	6, 12, 14, 26&27,	8
ONE INCH.								
Monthly mean, . . .	43.87	56.46	66.59	65.61	67.41	57.48	44.96	45.75
Extremes.								
Monthly maximum,	66	72	88	79.50	84	71.50	63.50	68.50
Date, ...	26,	28,	15,	7,	4,	9,	16,	2
Monthly minimum,	32.25	39.50	48.50	54	50.50	42	34	32
Date, ...	9,	3 & 17,	3,	13,	23,	29 & 30,	22,	17 & 18
Mean maximum, . .	49.06	59.4	71.70	72.31	75.46	62.21	49.67	51.93
" minimum, . .	38.33	51.46	61.29	60.01	55.69	53.28	39.62	40.92
Range.								
Monthly, ...	33.75	32.50	39.50	25.50	33.50	29.50	29.50	36.50
Meandaily, ...	10.52	7.74	10.72	10.50	10.78	8.91	8.02	11.34
Greatest daily, . . .	25.25	13.8	22	16.50	17.50	15.25	17.50	26.50

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Summary of Soil Temperature, 1888—CONTINUED.

	April.	May.	June.	July.	August.	September.	October.	November.
	Deg.—Fahr.	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*	*Deg.—Fahr.*
Date,	9,	21,	15,	25,	2,	14,	16,	1
Least daily,	3.25	3	1	4	2	5	3.50	1
Date,	14,	5 & 11,	29,	9 & 12,	21,	17,	14	18
THREE INCHES.								
Monthly mean,	43.87	55.31	67.96	66.63	67.80	58.12	48.46	46.18
Extremes.								
Monthly maximum,	62.50	68.5	82	75.50	79.50	67.75	54	64.75
Date,	30,	28,	21,	5,7 & 31,	4,	18,	1 & 6,	2
Monthly minimum,	34.25	37.8	48	54.50	53.25	43	36	35.50
Date,	8,	6,	3,	13,	23,	30,	22,	17
Mean maximum,	47.44	57.84	69.65	70.07	71.13	61.20	47.74	49.61
" minimum,	39.02	59.66	58.01	62.01	63.42	54.56	42.46	42.30
Range.								
Monthly,	6.42	30.7	34	21	26.25	24.75	18	29.25
Mean daily,	8.19	6.51	8.58	8.19	7.70	65.33	5.33	7.97
Greatest daily,	19	20	12.50	12.50	18.25	11	11.75	18
Date,	9,	4 & 6,	18,	25,	15,	14,	25,	2
Least daily,	2.50	2	1	3	2	3	.50	0
Date,	11,	30,	29,	12 & 18,	21 & 22,	20,	19,	18
SIX INCHES.								
Monthly mean,	43.54	54.96	65.80	66.53	67.86	59.02	46.18	47.28
Extremes.								
Monthly maximum,	59	64.5	77.75	73.25	75	65	54	49.25
Date,	30,	28,29 & 30,	18,	31,	4,6 & 8,	1,	1,	5
Monthly minimum,	36.50	44	51	58	57.50	43	39	36.50
Date,	22,	3,	1,	2,	23,	30,	22,	18
Mean maximum,	45.52	56.42	67.98	68.39	69.24	63.43	47.35	48.71
" minimum,	40.79	55.69	58.97	63.03	65.05	56.70	44.39	44.39
Range.								
Monthly,	22.50	20.5	26.75	15.25	17.50	22	15	12.75
Mean daily,	4.66	4.03	5.75	5.38	4.17	3.33	2.90	4.41
Greatest daily,	11	10.5	9.50	10.50	5.50	11	7	14.25
Date,	27,	4,	17,	26,	14 & 15,	7,	1,	1
Least daily,	1	1	1	1.50	.25	1	.25	.25
Date,	11,	8,11,15 & 30,	2,	1,7, & 18,	13,	21 & 25	21,	8

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Twelve Inches.								
Monthly mean, . . .	42.97	53.82	64.27	65.74	67.49	60.06	48.36	48.01
Extremes.								
Monthly maximum,	54	61	72	69.75	78.50	67.75	53.50	52
Date, ...	30,	30 & 31,	21,	31,	17,	5,	2,	7
Monthly minimum,	39	47	53	61.50	56	46	44.50	41
Date, ...	22,	3,	14,	2,	14,	30,	22,	18
Mean maximum, . .	43.57	53.85	65.43	66.40	70.57	60.54	48.76	48.54
Extremes.								
Mean minimum, . .	42.22	53.29	63.21	64.90	66.59	59.59	48	47.46
Range.								
Monthly, ...	15	14	19	8.25	12.50	21.75	9	11
Mean daily, ...	1.37	1.66	2.12	1.50	1.64	.97	.81	1.29
Greatest daily, . . .	3	9.5	10.50	5.50	11.50	4.75	2.75	2.75
Date, ...	26,	7,	4,	7,	16,	5,	1,	11
Least daily, ...	0	.3	.50	0	.50	0	0	.25
Date, ...	14,	29,	23 & 25,	9 & 27,	5, 17, 18, 19, 22 & 27,	13,	2, 8 & 24,	4
Twenty-four Inches.								
Monthly mean, . . .	42.14	51.50	60.89	63.38	65.56	63.62	50.48	48.91
Extremes.								
Monthly maximum,	48	57	67	65.50	68.50	63	55	52
Date, ...	30,	30 & 31,	23,	31,	9 & 10,	1 & 2,	1,	11
Monthly minimum,	38.75	47.5	51.50	61.50	62.75	55.50	48	45.50
Date, ...	5,	4 & 5,	3,	1, 2 & 3,	24, 25, 26, 30 & 31,	30,	23, 24 & 31,	15
Mean maximum, . .	42.33	51.85	61.15	63.49	65.75	60.53	53.55	49.29
" minimum, . .	41.89	51.14	59.78	61.24	65.44	60.23	50.40	48.83
Range.								
Monthly, ...	9.25	9.5	15.50	4	5.75	7.50	7	6.50
Mean daily, ...	.43	.70	.69	.24	.97	.31	.34	.52
Greatest daily, . . .	3.50	3.5	4.50	1	4.75	1	1.50	1
Date, ...	5,	24,	3,	13,	5,	14 & 22,	7,	10, 12 & 15
Least daily, ...	0	0	0	0	0	0	0	0
	11 days.	7 days.	8 days.	15 days.	9 days.	8 days.	11 days.	5 & 8

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SOIL MOISTURE.

Water acts upon the plant not only as a food far more abundantly consumed than any mineral ingredient of the soil, but also as the medium by means of which the stores of other food in the soil are conveyed to the plant, and diffused through it. Experimenters in the field are too often forced to reject results because of differences in moisture of the plots upon which their crops are grown, differences so slight as to be scarcely visible to the eye, but showing clearly in the character of the growth obtained.

An attempt has, therefore, been made during the past year to keep track from week to week of the variations in the moisture of the soil of the Station farm. For this purpose a smooth piece of sod was selected, and sampled every week by driving an iron tube one and a-half inches in diameter, into the soil to a depth of six inches, and then withdrawing it, taking out the soil from within the tube and making a moisture determination. This determination was not an absolute one, but only a determination of loss by air-drying, although great care has been exerted to maintain the conditions of this operation quite constant. The soil is a moderately heavy loam, usually quite a good deal heaved by frost, and having scattered through it large numbers of small pieces of flint, which are continually working to the surface. The mechanical condition is usually good and open, and the whole soil is naturally underdrained by the porous limestone upon which it lies.

Mr. G. L. Holter had immediate charge of these observations, the results of which are presented in the following table:

Soil Moistures.

DATE.	Intervening rain-fall.	Days since last rain.	Loss in air-drying.	DATE.	Intervening rain-fall.	Days since last rain.	Loss in air-drying.
	Inches.		*Per cent.*		*Inches.*		*Per cent.*
*April 30,		10	31.5	Aug. 6,	0.52	1	14.0
May 8,	.54	8	38.0	" 13,	1.57	1	45.0
" 14,	2.19	0	40.0	" 20,	0.37	3	38.0
" 21,	1.09	3	38.5	" 27,	2.47	6	46.0
" 28,	1.23	2	39.5	Sept. 3,	1.23	3	52.0
June 3,	1.61	1	33.0	" 10,	1.21	2	50.0
" 11,	0.27	0	33.5	" 17,	0.94	0	†55.0
" 18,	.00	8	17.0	" 20,	0.97	0	†68.0
July 2,	2.04	6	38.0	Oct. 15,	1.78	2	41.0
" 10,	1.00	0	42.0	" 22,	1.35	3	29.0
" 16,	0.75	4	32.0	" 30,	0.68	2	51.0
" 23,	0.96	4	38.0	Nov. 5,	0.15	2	40.0
" 30,	0.07	3	20.0	" 12,	0.89	2	35.0

*Dry weather for ten days before.
†After a driving shower.

WEEKLY CROP REPORTS.

At the request of the United States Signal Service and the Pennsylvania State Weather Service, the Station has made weekly observations upon the development of the general farm crops as affected

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by the principal meteorological conditions. These observations were made by Mr. William H. Caldwell, under the general supervision of the writer. For the sake of the light they may throw upon the conditions under which the field work of this year has been performed, to aid in comparing climates in different portions of the State, and to make a permanent record with which comparison may be made in succeeding years, the reports are tabulated below in much the form in which they were transmitted to the State Weather Service.

These reports were made weekly from Friday, April 20, through Friday, October 12, the weekly summary being made up for the week ending at 9 P. M. of the Thursday preceeding.

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Weekly Crop Reports.

Date.	Rainfall.	Temperature.	Sunshine.	Remarks.
April 20, .	Above average; well distributed; more than 0.1 in. on three days; April 16, ¼ in. of snow.	Slightly above average, .	Little, ...	Wheat excellent; rye backward; excessive moisture delays sowing of oats.
" 27, .	Below average; fairly distributed; more than .1 in. on 1 day; 20th, 0.21 in. Slight snow on 21st.	Below average, ...	Much, ...	Oats and barley sown; soil in good condition; wheat and rye benefited by sunshine.
May 4, . .	Below average; badly distributed; more than 0.1 in. on 1 day; May 1st., .06 in.	Below average, ...	Average amount,	Spring grains coming up; foliage and blossoms on trees appearing.
" 11, . .	Above average; well distributed; more than .1 in. on 5 days; weekly total, 2.05 in.	About average, ...	Little, ...	Excessive moisture has delayed corn planting; otherwise an excellent growing week; foliage on fruit trees and maples well developed.
" 18, . .	Above average; well distributed; more than .1 on 1 day, .44 in. on 12th.	Below average, ...	Little, ...	Cool, moist week; corn planting done between showers; growing crops retarded by lack of heat and sun.
" 25, . .	Above average; fairly distributed; more than .1 on 3 days; 1.94 in. for week.	Below average, ...	Very Little, . . .	Corn coming up slowly; wheat and rye doing well; need heat and sunshine.
June 1, .	Above average; fairly distributed; more than .1 on 2 days; 1.58 in. for week.	About average, ...	Little, ...	Corn coming up slowly; oats backward, other crops doing nicely.
" 8, .	Below average; well distributed; more than .1 in. on 1 day; .37 in. for week.	Below average, ...	Average, ...	Seed germination retarded; many seeds rotted.
" 15, .	Below average; more than .1 on 1 day; 11th, .2 in.	About average, ...	Much, ...	Increased warmth and sunshine affecting crops very favorably; wheat well headed and in good condition; corn and vegetables doing well; oats backward.
" 22, .	Below average; badly distributed; more than .1 in. on 1 day; 21st, .6 in.	Above average, ...	Very much, . . .	The dry weather has greatly helped grain and corn, there being enough rain to prevent drought. Wheat well headed, and grass in excellent condition and ready to cut.
" 29, .	About average; well distributed; more than .1 in. on 2 days; 1.42 in. for week.	Average, ...	Average, ...	Wheat yellowing nicely; oats heading well, and corn growing rapidly.
y 6, . .	No rain.	Below average, ...	Much, ...	Weather very favorable for hay harvest, which is well advanced; wheat ready for cutting; earlier variety of oats beginning to ripen.
" 13, . .	Above average; well distributed; more than .1 in. on 2 days; 1.60 for week.	Below average, ...	Much, ...	Hay harvest completed; wheat harvest begun; corn, oats and barley excellent.
" 20, . .	Above average; fairly distributed; more than .1 in. on 1 day; .96 in. for week.	Below average, ...	Much, ...	Rain hindered slightly the field curing of wheat; all standing crops in good condition.
" 27, . .	No rain.	Below average, ...	Much, ...	Fair weather has advanced growth of corn and ripening of oats.
Aug. 3, .	Below average; fairly distributed; more than .1 in. on 1 day; .22 in. for week.	Below average, ...	Much, ...	Corn doing well; oats well ripened and harvest begun.
" 10, .	Below average; badly distributed; more than .1 in. on 1 day; .37 in. on 5th.	Above average, ...	Much, ...	Warm, sunny weather and showers have greatly benefited corn, and potatoes are doing well; oats harvest nearly done, with crop in good condition.
" 17, .	No rain.	Average, ...	Much, ...	Corn needs rain; oats harvest completed.
" 24, .	Above average; well distributed; 2.47 in. on 21st; 2.84 in. for week.	Average, ...	Average, ...	Corn and potatoes benefited by the rain.
" 31, .	None.	Average, ...	Average, ...	Corn and potatoes done growing; soil is sufficiently moist to secure rapid maturing of corn in the ear.

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Sept. 7,	Average; well distributed; 1.23 in. on August 31st.	Below average,	Very little,	Seed wheat coming up nicely; ripening of corn in ear retarded by lack of sunshine.
" 14,	Above average; fairly distributed; 1.20 in. on 8th; 1.23 in. for week.	Below average,	Average,	Soil moisture has affected wheat favorably; late potatoes are not ripening well from lack of sunshine and warmth.
" 21,	Above average: well distributed, 1.91 in. for week.	Below average,	Very little,	Winter wheat all sown and in good condition; potatoes late in ripening.
" 28,	Below average; or .03 for week. Heavy fogs.	Below average,	Much,	Winter wheat doing well; corn cutting well under way, and weather favorable for field curing.
Oct. 5,	About average; fairly distributed; over .1 on 1 day; .59 for week.	Below average,	Average,	Wheat growing well; potatoes being raised although ground is a little too damp; corn all cut.
" 12,	Below average; fairly distributed; over .1 on 1 day; .38 for week; cloudy and misty.	Below average,	Little,	Damp cloudy weather prevented drying of corn stover, and is not good for potato raising; potato crop yielding well.

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NOTES ON THE METEOROLOGY OF 1888.

To represent still more compactly the seasons of 1888 in their relation to agriculture, a summary is presented below of those data most important, from an agricultural point of view, grouped so as to show the totals for January to December, 1888, and also the winter of 1887–8 (October to March), and the growing season of 1888 (April to September); and to this there are added a few of the most important notes on the growing season, as indicated by the development of the crops of the year.

Annual Summary.

Mean barometer for the year,	30.063	inches.
Highest " " (February 15),	30.972	"
Lowest " " (July 18),	29.004	"
Mean annual temperature,	46.58	Deg. Fahr.
Highest (June 21),	95	"
Lowest (February 10),	—13	"
Annual range of temperature,	108	"
Mean daily range for the year,	18.14	"
Greatest " " (February 15),	40.5	"
Least " " (August 21),	3	"
Mean daily relative humidity,	71.81	per cent.
Annual rainfall,	40.62	inches.
Greatest monthly rainfall (May),	6.26	"
Least " " (February),	1.70	"
Greatest daily " (August 21),	2.47	"
Number of days on which .01 inch or more of rain fell,	127	
Mean percentage of cloudiness,	56.34	
Days on which cloudiness averaged 80 per cent. or more,	131	
Wind, total movement,	20,210.9	miles.
" maximum velocity (January 26),	34.8	"
" greatest daily movement (December 18),	372.4	"

Winter of 1887–8.

Mean temperature, October, 1887, to March, 1888,	32.78	Deg. Fahr.
Lowest " (February 10, 1888),	—13	"
Total rainfall (including rain and snow),	12.21	inches.
" snowfall,	46.30	"
Greatest monthly snowfall (January),	17.15	"
Greatest daily " (March 11),	8.00	"
Number of days on which snow fell,	25	
Number of days when cloudiness averaged 80 per cent. or more,	84	

Growing Season of 1888.

Mean atmospheric temperature, April to September,	61.68	Deg. Fahr.
Highest " " (June),	95	"
Lowest " " (April),	20	"
Mean daily range,	21.13	"
Greatest " (April),	37	"

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Soil temperature (April to September)—

Daily mean, at surface,	61.30	"
" " 1 inch depth,	59.57	"
" " 3 "	59.91	"
" " 6 "	59.62	"
" " 12 "	59.06	"
" " 24 "	57.85	"

Soil temperature—

Highest recorded temperature, at surface (June 21),	97	"
Highest recorded temperature, at 1 inch depth (June 15),	88	"
Highest recorded temperature, at 3 inch depth (June 21),	82	"
Highest recorded temperature, at 6 inch depth (June 18),	77.75	"
Highest recorded temperature, at 12 inch depth (August 17),	78.50	"
Highest recorded temperature, at 24 inch depth (August 9 and 10),	68.50	"
Lowest recorded temperature, at surface (April 7),	31	"
Lowest recorded temperature, at 1 inch depth (April 9),	32.25	"
Lowest recorded temperature, at 3 inch depth (April 8),	34.25	"
Lowest recorded temperature, at 6 inch depth (April 22),	36.50	"
Lowest recorded temperature, at 12 inch depth (April 22),	39	"
Lowest recorded temperature, at 24 inch depth (April 5),	38.75	"
Mean daily range, at surface,	20.59	"
" " 1 inch depth,	9.86	"
" " 3 "	7.62	"
" " 6 "	4.55	"
" " 12 "	1.54	"
" " 24 "	0.45	"
Greatest daily range, at surface (April 28),	40	"
" " 1 inch depth (April 9),	25.25	"
" " 3 " (May 4 and 6),	20	"
" " 6 " (April 27 and September 7),	11	"
Greatest daily range, at 12 inch depth (August 16),	11.50	"
" " 24 " (August 5),	4.75	"
Last frost in spring,	April 13	
First " fall,	September 12	
Mean relative humidity,	72.94	per cent.
Total rainfall,	23.7	inches.
Heaviest daily rainfall (August 21),	2.47	"
Number of days on which .01 inch or more fell,	50	
Mean percentage of cloudiness,	47.96	
Number of days on which cloudiness averaged 80 per cent. or more,	46	
Average hours of sunshine per day,	7 hours 19 minutes.	
Mean percentage of soil moisture lost in air drying,	38.3	

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Principal Periods of Crop Development.

Wheat—	
Headed,	June 8
Ripened,	July 6
Harvested,	July 13 to 20
Hay—	
Ready to cut,	June 22
Harvest ended,	July 13
Oats—	
Sown,	April 27
Earlier varieties ripening,	July 6
Harvested,	August 3 to 17
Corn—	
Sown,	May 18
Cut,	Sept. 21 to Oct. 5

The winter was not most favorble to grain, since the snow, although falling frequently, was badly drifted and the hills laid bare; there was therefore considerable loss by winter-killing. The spring was late and wet, plowing and planting being retarded and vegetation advancing slowly: many seeds germinated badly, vegetables, especially, rotting. The weather changed during June to September, the rainfall being badly distributed, and vegetation was retarded by lack of warmth and sunshine; for only a short period the soil seem deficient in moisture. All early harvests, but that of wheat, were completed in excellent weather. The later season was cold, damp and cloudy, interfering with the ripening of corn and potatoes, making the harvest of the latter difficult, and injuring the corn stover greatly during field curing.

WEATHER SIGNALS.

By arrangement with the State Weather Service and through the courtesy of the Pennsylvania railroad, the Station is in daily receipt of the weather predictions for Pennsylvania, issued by the United States Signal Office. These predictions cover the weather (whether rainy or fair), temperature and wind for the day of issue. To secure a speedy and widespread dissemination of these predictions, the State Weather Service has issued signal flags, by means of which the weather and temperature for twenty-four hours after 7 A. M. of the day for which prediction has been made may be indicated. These flags the Station displays from the flagstaff on top of the College tower, whence they are visible for miles on every side.

There are four flags in each set: a square white one, to indicate fair weather; a square blue one, to indicate rain; a triangular black flag, which indicates a higher or lower temperature, according as it is displayed above or below the weather flags when they are strung on a vertical halyard; if the prediction is for fair weather, followed by rain, the blue flag is placed upon the halyard as well as the white, but below

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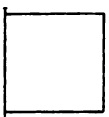
WEATHER SIGNALS

ADOPTED FOR GENERAL USE BY THE SIGNAL SERVICE ON AND AFTER MARCH 1, 1887.

No. 1.
White Flag.

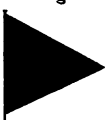


Clear or fair weather.

No. 2.
Blue Flag.

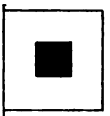
Rain or snow.

No. 3.
Black Triangular Flag.



Temperature Signal.

No. 4.
White Flag with black square in centre.

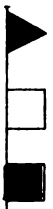


Cold wave.

DISPLAYED FROM POLES.

Fair weather. Colder.

Warmer. Rain or snow.

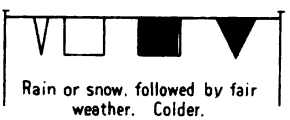


Warmer fair weather, followed by rain or snow.

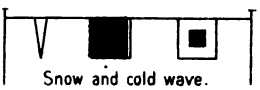
Fair weather. Cold wave.

DISPLAYED FROM HORIZONTAL SUPPORTS.

Warmer, fair weather.

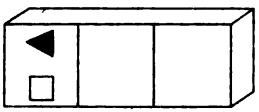


Rain or snow, followed by fair weather. Colder.

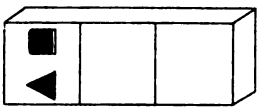


Snow and cold wave.

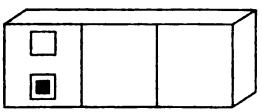
DISPLAYED ON CARS.



Warmer fair weather.



Fair weather, followed by rain. Colder.



Fair weather. Cold wave.

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the latter. In case the display is made from a horizontal support, the point at which reading should begin is indicated by a small streamer.

There is a fourth flag in the set, a square white with a black square in the center. This is the cold wave flag, and indicates a drop in temperature to forty-five degrees or less and is usually ordered twenty-four hours in advance. When it is displayed the black triangular flag is omitted.

A clear idea of the method of display may be obtained from the following plate, published through the courtesy of the State Weather Service.

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INSTRUCTIONS FOR TAKING AND SENDING SAMPLES.

This Station will undertake, as far as its means permit, the gratuitous examination of samples of agricultural and horticultural products sent to it by citizens of the State on condition.

First. That samples are taken in accordance with the instructions printed below, and that each sample is accompanied by a printed form for description of sample* properly filled out.

Second. That the results are likely to be of use to the public.

Third. That the Station has full liberty to publish the results or otherwise use them at its discretion for the public good.

No work of a purely private character, or which has no direct bearing upon agriculture or horticulture can be undertaken. In case more samples should be sent at any time than can be examined, the Station reserves the right to select for examination those which, in its judgment, are of most general interest.

FOLDERS.

Coarse Fodder.—In the sampling of coarse fodders, such as hay, corn fodder, etc., much care is necessary to secure a fair sample. Several rather large portions should be taken from different parts of the mow, stack or shed; of hay, five or six forkfuls, one from a place and from different depths in the mow if possible; of corn fodder, at least six bundles, each from different parts of the lot. Run the fodder through a feed cutter, cutting it as fine as possible, shovel over the cut fodder on a tight floor so as to mix it thoroughly, spread it out about six inches deep, and take from at least six different parts of this layer not less than a bushel of the fodder in all, being careful to take all the fodder down to the floor in each spot so as not to lose any of the finer parts. Put it in a clean grain bag or other suitable receptacle, weigh it, and send at once to the Station.

Green Fodder. In sampling green forage in the field, cut all the fodder on a measured area of not less than a square rod, and better of several rods in different portions of the field. Weigh the green fodder at once, dry it on sheets or hay caps until dry enough to keep during transit (do not over-dry), weigh again, run the whole through the feed cutter, and take a sample as described under coarse fodder, recording the weight of the sample.

Grain and Meal.—Take several small portions from different parts of the bin, or from every fifth or tenth bag, mix thoroughly, and send not less than a quart of the mixture in a sealed glass bottle or jar, or a tightly-closed tin can, securely packed. Of ear corn not less

*These forms will be furnished free upon application. In writing for them, state what it is proposed to sample, as we have several different forms.

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than half a bushel should be sent, selected from different portions of the crib.

Roots and Potatoes.—Select a number of specimens of as nearly as possible average size. Send them whole.

When grain or meal can be sent in a tightly-closed package it is not necessary to weigh the sample. In all other cases this must be done. The form for description of sample contains three blanks for recording weights. The first two are for use when green fodder is sampled; only the third need be filled out when dry fodder is sampled.

DAIRY PRODUCTS.

Milk.—If possible, communicate with the Station before sending so perishable an article as milk, especially in hot weather. Mix thoroughly together the whole of the milk to be sampled, either by pouring from one vessel to another and back several times or by very thorough stirring. From the mixed milk take at once a sample of not less than a pint, place it in a sealed bottle or jar and send at once, securely packed, by some speedy conveyance. Fill the bottle *full*, to avoid churning on the way, and in warm weather add to a quart sample as much salicylic acid as can be held on a dime, to hinder souring. It is very desirable that the sample shall not be sour when it reaches the Station, and all possible precautions to prevent it should be taken.

In sampling milk from cows or herds the whole of one milking should be sampled.

Butter and Cheese.—A sample of at least half a pound is required, taken from different portions of the lot. It should be sent in a glass jar or bottle or tightly-closed tin can to avoid any loss of water, and should be forwarded as promptly as possible. Send as full particulars as possible in addition to those called for in the form for description.

SEEDS.

Great care should be taken in sampling seed, by carefully mixing the contents of the bag, barrel or other package in which they are contained, and drawing samples from different parts, finally mixing these and taking the necessary amount for the sample to be sent. Compare the instructions for sampling grain and meal.

Of the smaller seeds—red top, white clover, etc.—send four (4) ounces; of beet, turnips, etc., eight (8) ounces; of grains, peas, beans, etc., one (1) pound.

SPECIMENS FOR IDENTIFICATION.

All samples of plants, grasses, weeds, etc., sent to be named should include the whole plant; root, stem, leaves, flowers and fruit. If too large to be sent whole, send portions of each of the above parts. Plants should, if possible, be sent *when in blossom*, and with speci-

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mens of the fruit or seed more or less mature, when the latter can be obtained.

Insects should not be enclosed in a letter; but, if dead, they should be packed in cotton or paper and enclosed in a stout box; if alive, they should be placed in a *tight* tin or wooden box, along with a supply of their appropriate food. Air holes in the box are not needed. Each package should be marked with the name of the sender. The rate of postage on matters of this kind is one cent per ounce.

SOIL AND MUCK.

The Station does not ordinarily undertake to make soil analyses, as the results are not usually of sufficient value to warrant the expense. No samples of soil or muck should be sent without first consulting the Director of the Station.

COMMERCIAL FERTILIZERS.

Persons desiring analyses of fertilizers should communicate with the Secretary of the State Board of Agriculture, Harrisburg, Pa.

IN GENERAL.

Packages containing samples or specimens for examination should be plainly marked with contents and name and address of sender, and be sent, *charges prepaid*, to DIRECTOR OF AGRICULTURAL EXPERIMENT STATION, STATE COLLEGE, *Centre county*, *Pa.* The Station cannot pay express charges on samples. A letter should at the same time be sent, notifying the Station of the sending of the sample, and giving such particulars as to the origin of the sample and the reasons for wishing it examined as are not contained in the form for description. We are sometimes at a loss to know what course to take with a sample because we do not know on what point the sender wishes information.

Particular care should be taken to fill out the form for description of sample carefully and fully. This should be done *at the time the sample is taken*, while the particulars are freshly in mind. Samples should also be forwarded promptly as soon as taken.

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EXCHANGES.

The publications of this Station are mailed regularly to all the leading agricultural papers of the country, as well as to all newspapers in the State. The following agricultural papers have been sent to the Station regularly, during the whole or a part of the year, in exchange:

Pacific Rural Press,	San Francisco, Cal.
Connecticut Farmer,	Hartford, Conn.
Southern Cultivator,	Atlanta, Ga.
Breeders' Gazette,	Chicago, Ill.
Farmers' Review,	"
National Live Stock Journal,	"
Orange Judd Farmer,	"
Prairie Farmer,	"
Western Rural,	"
Drainage and Farm Journal,	Indianapolis, Ind.
Indiana Farmer,	" "
Jersey Bulletin,	" "
Sorghum Grower's Guide,	Madison, Ind.
The Industrialist,	Manhattan, Kans.
Sugar Bowl,	New Orleans, La.
New England Farmer,	Boston, Mass.
Weekly Globe,	"
New England Homestead,	Sprinfigeld, Mass.
Farm and Home,	" "
Farm, Stock and Home,	Minneapolis, Minn.
Northwestern Agriculturist,	" "
Western Resources,	Lincoln, Neb.
Mirror and Farmer,	Manchester, N. H.
The Press,	Deckertown, N. J.
Farmers' Club Journal,	Hornellsville, N. Y.
American Agriculturist,	New York city, N. Y.
American Dairyman,	" "
Orange County Farmer,	Port Jervis, N. Y.
American Grange Bulletin,	Cincinnati, Ohio.
Ohio Farmer,	Cleveland, Ohio.
Farm and Fireside,	Springfield, Ohio.
Farm Journal,	Philadelphia, Pa.
Sugar Beet,	" "
Weekly Press,	" "
Hoard's Dairyman,	Fort Atkinson, Wis.
Western Farmer,	Madison, Wis.

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Office and Laboratory Building.

EXPERIMENT STATION.

Farm Buildings.

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APPENDIX.

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Meteorological Records for 1888. Barometric Pressure in Inches. (Corrected and Reduced.)

DATES.	JANUARY.				FEBRUARY.				MARCH.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	29.872	29.701	29.868	29.814	30.309	30.311	30.408	30.343	30.336	30.298	30.324	30.318
2,	30.090	30.149	30.184	30.183	30.481	30.374	30.387	30.414	30.295	30.151	30.005	30.150
3,	30.142	30.201	30.288	30.210	30.348	30.318	30.351	30.337	30.229	30.212	30.354	30.268
4,	30.234	30.049	30.048	30.112	30.170	29.945	29.762	29.961	30.341	30.238	30.348	30.372
5,	30.258	30.218	30.452	30.309	29.856	29.865	29.955	29.892	30.127	30.006	30.002	30.045
6,	30.319	30.074	30.043	30.145	30.135	30.125	30.122	30.126	30.066	30.085	30.069	30.068
7,	29.902	29.845	29.914	29.887	30.033	29.950	29.882	29.955	30.041	30.023	30.166	30.077
8,	29.941	30.039	30.303	30.094	29.692	29.717	29.988	29.782	30.196	30.191	30.401	30.263
9,	30.458	30.393	30.228	30.358	30.074	30.097	30.332	30.168	30.471	30.427	30.500	30.466
10,	29.995	30.013	30.171	30.059	30.351	30.215	30.147	30.238	30.468	30.316	30.366	30.350
11,	30.385	30.463	30.755	30.534	30.050	29.972	30.084	30.035	30.055	29.954	30.198	30.069
12,	30.879	30.758	30.639	30.757	30.140	30.107	30.124	30.124	30.289	30.211	30.218	30.228
13,	30.338	30.127	30.339	30.268	30.249	30.182	30.190	30.207	29.994	29.895	30.016	29.965
14,	30.599	30.581	30.427	30.519	30.160	29.992	30.201	30.118	30.108	30.163	30.326	30.199
15,	30.201	30.227	30.071	30.764	30.691	30.720	30.792	30.710	30.393	30.305	30.202	30.300
16,	30.877	30.854	30.840	30.857	30.709	30.445	30.133	30.429	29.979	29.857	29.967	29.934
17,	30.577	30.312	30.104	30.331	30.046	29.968	29.969	29.994	29.950	29.851	29.968	29.939
18,	30.169	30.106	30.183	30.153	29.953	30.088	30.266	30.102	30.118	30.088	30.179	30.128
19,	30.310	30.194	30.225	30.243	30.327	30.190	30.115	30.207	30.215	30.102	30.028	30.115
20,	30.144	30.211	30.364	30.239	29.910	29.779	29.882	29.857	29.857	29.688	29.659	29.735
21,	30.491	30.496	30.669	30.552	30.124	30.145	30.257	30.175	29.365	29.579	29.808	29.580
22,	30.728	30.602	30.619	30.648	30.345	30.326	30.420	30.364	29.959	30.007	30.288	30.068
23,	30.630	30.333	30.219	30.394	30.337	30.170	30.211	30.239	30.320	30.272	30.328	30.307
24,	30.450	30.489	30.546	30.495	30.278	30.208	30.024	30.170	30.328	30.259	30.425	30.337
25,	30.893	30.088	29.846	30.092	29.701	29.575	29.658	29.648	30.537	30.501	30.490	30.509
26,	29.859	29.862	30.077	29.933	29.790	29.804	29.950	29.848	30.357	30.150	30.142	30.226
27,	29.993	29.985	30.129	30.036	30.000	29.950	30.242	30.064	30.173	30.148	30.062	30.126
28,	30.178	30.099	30.235	30.170	30.450	30.408	30.390	30.416	29.936	29.821	29.721	29.826
29,	30.258	30.111	30.096	30.150	30.356	30.296	30.332	30.328	29.977	30.090	30.194	30.087
30,	30.022	29.941	29.956	29.973	.....	.....	.....	.....	30.365	30.132	29.990	30.109
31,	29.981	30.011	30.189	30.060	.....	.....	.....	.....	30.079	30.065	30.187	30.110
Means,	30.279	30.210	30.194	30.248	30.171	30.455	30.155	30.161	29.882	30.414	30.153	30.134

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Meteorological Records for 1888. Barometric Pressure in Inches—CONTINUED.

DATES.	APRIL.				MAY.				JUNE.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	30.122	29.980	29.805	29.969	29.790	29.873	30.012	29.892	29.690	29.698	29.908	29.765
2,	29.558	29.691	29.993	29.747	30.118	30.129	30.202	30.149	29.901	29.810	30.004	29.915
3,	30.166	30.140	30.271	30.192	30.278	30.155	30.123	30.185	30.054	29.989	30.081	30.041
4,	30.380	30.288	30.357	30.342	30.124	29.991	29.998	30.034	30.179	30.121	30.185	30.162
5,	30.201	29.987	29.798	29.991	30.070	30.079	30.175	30.108	30.268	30.170	30.153	30.197
6,	30.073	30.148	30.241	30.154	30.268	30.164	30.229	30.220	30.120	30.021	29.980	30.040
7,	30.230	30.168	30.345	30.248	30.325	30.211	30.246	30.261	30.145	30.168	30.167	30.160
8,	30.450	30.382	30.414	30.339	30.239	30.160	30.109	30.169	30.218	30.122	30.135	30.158
9,	30.489	30.351	30.322	30.387	29.996	29.861	29.910	29.932	30.108	30.026	29.940	30.025
10,	30.212	29.921	29.813	29.982	29.920	29.875	29.918	29.914	29.930	29.828	29.732	29.830
11,	30.047	30.125	30.193	30.122	29.980	29.932	29.839	29.917	29.795	29.900	30.091	29.929
12,	30.174	30.164	30.383	30.240	29.748	29.717	29.879	29.781	30.182	30.134	30.164	30.160
13,	30.440	30.170	30.164	30.291	29.985	29.861	29.885	29.910	30.168	30.086	30.042	30.097
14,	29.866	29.989	30.099	29.968	29.872	29.843	29.966	29.894	30.020	29.903	30.001	29.975
15,	30.152	30.005	29.945	30.034	30.025	30.014	30.028	30.022	29.952	29.882	29.909	29.914
16,	29.978	30.069	30.266	30.104	29.968	29.951	30.129	30.016	29.854	29.808	29.925	29.862
17,	30.384	30.319	30.262	30.322	30.186	30.122	30.148	30.152	29.984	29.820	29.910	29.905
18,	30.093	30.055	30.149	30.099	30.019	29.913	29.850	29.927	29.894	29.839	29.866	29.866
19,	30.101	29.993	29.991	30.028	29.988	30.072	30.251	30.104	29.999	29.906	29.978	29.959
20,	30.015	30.083	30.149	30.066	30.297	30.182	30.277	30.252	30.008	29.825	29.735	29.856
21,	30.147	30.094	30.118	30.119	30.289	30.180	30.183	30.217	29.894	29.683	29.786	29.818
22,	30.108	29.927	29.943	29.991	30.201	30.128	30.133	30.154	29.831	29.768	29.817	29.805
23,	29.910	30.023	30.145	30.053	30.112	29.997	30.001	30.037	29.780	29.760	29.969	29.808
24,	30.244	30.282	30.492	30.339	29.953	29.945	29.974	29.957	29.929	29.739	29.756	29.808
25,	30.597	30.509	30.530	30.545	29.957	29.918	29.928	29.933	29.833	29.810	29.842	29.828
26,	30.571	30.406	30.436	30.471	29.919	29.919	29.983	29.940	29.790	29.811	29.797	29.860
27,	30.483	30.352	30.384	30.406	29.930	29.801	29.821	29.851	30.076	30.052	30.001	30.043
28,	30.355	30.177	30.141	30.224	29.802	29.740	29.781	29.774	29.893	30.010	29.998	29.967
29,	30.082	29.927	29.952	29.987	29.836	29.784	29.830	29.817	29.943	30.143	30.320	30.135
30,	29.921	29.786	29.821	29.826	29.850	29.882	30.020	29.901	30.145	29.986	29.949	30.027
31,	.....	.....	.....	.....	29.762	29.607	29.761	29.710	.....	.....	.....	.....
Means,	30.187	30.112	30.168	30.154	30.028	29.966	30.020	29.982	30.019	29.928	29.968	29.964

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Meteorological Records for 1888. Barometric Pressure in Inches—Continued.

Dates.	July.				August.				September.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	29.965	30.011	30.102	30.026	30.009	29.967	30.150	30.042	29.851	29.877	30.039	29.922
2,	30.219	30.097	30.184	30.166	30.028	29.963	29.925	29.972	30.131	30.070	30.223	30.141
3,	30.187	30.135	30.136	30.126	30.028	29.963	29.925	29.972	30.331	30.196	30.136	30.221
4,	30.087	29.998	30.007	30.030	29.881	29.736	29.914	29.843	30.135	30.165	30.043	30.114
5,	29.994	29.882	29.967	29.946	29.854	29.840	29.908	29.834	30.132	30.191	30.315	30.213
6,	30.074	30.057	30.090	30.077	29.877	29.725	29.981	29.877	30.486	30.456	30.509	30.484
7,	29.980	29.894	30.030	29.961	29.953	29.883	29.854	29.930	30.317	30.472	30.460	30.383
8,	30.090	. . . .	30.003	30.046	29.921	29.842	29.992	29.918	30.107	30.091	30.075	30.091
9,	29.892	29.914	29.980	29.928	30.010	30.024	30.122	30.075	30.094	29.963	29.941	30.006
10,	29.977	29.908	29.892	29.926	30.309	30.345	30.275	30.276	30.060	30.019	30.157	30.079
11,	29.967	29.809	29.612	29.796	30.346	30.189	30.270	30.268	30.177	30.044	30.070	30.097
12,	29.909	29.858	29.852	29.873	30.146	30.101	29.925	30.057	30.088	30.047	30.029	30.088
13,	29.967	29.981	30.066	29.971	30.148	30.045	30.106	30.099	30.119	29.996	30.010	30.072
14,	30.189	30.097	29.939	30.075	30.184	30.116	30.126	30.142	30.297	30.156	30.204	30.217
15,	30.194	30.096	30.092	30.127	30.174	30.018	30.039	30.077	30.228	30.188	30.136	30.182
16,	30.194	30.117	30.181	30.492	30.094	30.044	30.048	30.060	30.140	29.715	29.827	29.894
17,	30.685	30.117	30.610	30.480	30.082	29.972	30.087	30.078	30.084	30.010	29.871	29.972
18,	29.004	30.164	30.108	30.177	30.089	30.045	30.116	30.066	30.186	30.066	30.184	30.129
19,	30.043	29.978	30.126	30.047	30.064	30.016	30.021	30.040	30.179	30.081	30.140	30.117
20,	30.249	30.046	30.003	30.099	30.077	30.105	30.060	30.080	30.110	30.031	30.070	30.071
21,	29.645	29.125	30.281	29.684	29.858	29.618	29.694	29.728	30.079	30.066	30.168	30.108
22,	29.093	30.000	30.052	29.715	29.890	29.979	30.163	29.677	30.238	30.047	30.179	30.151
23,	30.023	29.913	30.021	29.986	30.276	30.178	30.175	30.208	30.228	30.134	30.160	30.174
24,	30.055	29.978	30.128	30.053	30.162	30.111	30.088	30.120	30.226	30.176	30.147	30.183
25,	30.214	29.975	30.089	30.092	30.098	30.046	30.050	30.064	30.060	29.973	29.872	29.968
26,	30.052	. . . . .	29 924	29.988	29.994	30.017	30.000	30.000	29.812	29.766	29.703	29 761
27,	30.080	30.012	30.018	30.033	29.945	30.029	30.058	30.017	29.829	29.820	29.003	29.884
28,	30.160	. . . . .	30.248	30.186	30.196	30.088	30.017	30.117	30.088	30.063	30.108	30.085
29,	30.051	30.089	30.129	30.089	29.064	. . . .	30.027	29.545	30.168	30.083	30.176	30.142
30,	30.035	29.978	30.058	30.028	30.060	29.907	29.939	29.968	30.207	29.996	29.967	30.056
31,	29.981	29.924	29.886	29.930	29.983	29.909	29.861	29.917	. . .	. . .	. . . . .	. . . . .
Means,	30.199	27.087	30.059	30.085	30.288	30.656	30.003	30.003	30.131	30.064	30.097	30.098

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Meteorological Records for 1888. Barometric Pressure in Inches—CONTINUED.

DATES.	OCTOBER.				NOVEMBER.				DECEMBER.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	29.781	29.862	29.455	29.692	30.360	30.208	30.220	30.261	30.002	30.041	30.073	30.039
2,	29.639	29.711	29.875	29.741	30.158	30.000	29.963	30.047	30.191	30.112	30.160	30.154
3,	30.062	30.042	30.136	30.068	29.837	29.948	30.311	30.080	30.160	30.120	30.026	30.102
4,	30.169	30.094	30.184	30.109	30.270	30.210	30.317	30.282	29.996	29.973	29.866	29.933
5,	30.169	30.028	30.082	30.076	30.226	30.163	30.082	30.157	29.743	29.670	29.686	29.699
6,	29.918	29.928	29.921	29.920	30.088	29.885	29.988	29.954	30.088	30.143	30.269	30.167
7,	29.937	29.789	29.700	29.822	30.193	30.193	30.357	30.248	30.155	30.094	30.114	30.121
8,	29.704	29.719	29.879	29.766	30.342	30.208	30.726	30.225	30.216	30.018	29.955	30.061
9,	29.894	29.954	29.964	29.904	29.930	29.870	29.742	29.847	29.980	30.043	30.077	30.033
10,	30.084	29.925	30.053	30.042	29.631	29.630	29.747	29.669	30.090	29.906	29.915	30.010
11,	29.937	29.852	29.749	29.846	29.958	30.076	30.193	30.074	29.874	29.850	29.836	29.853
12,	29.639	29.766	29.721	29.708	30.279	30.258	30.409	30.314	29.981	30.018	29.962	29.992
13,	. . . .	. . . .	29.877	29.677	30.442	30.450	30.436	30.436	29.980	29.949	29.939	29.956
14,	29.599	30.082	30.180	26.920	30.464	30.308	30.278	30.347	30.299	30.259	30.509	30.356
15,	30.077	29.960	30.022	30.026	30.206	29.858	29.873	29.970	30.585	30.438	30.257	30.403
16,	29.997	29.944	30.018	29.984	29.851	29.885	30.064	29.933	30.010	30.040	29.899	30.018
17,	30.087	30.171	30.229	30.142	30.355	30.464	30.646	30.488	29.727	29.571	30.244	29.847
18,	30.290	30.179	30.202	30.223	30.668	30.718	30.546	30.642	29.548	30.119	29.849	29.839
19,	30.045	29.824	29.784	29.884	30.367	30.320	30.333	30.340	29.975	30.297	30.318	29.863
20,	29.878	29.948	29.968	29.968	30.443	30.487	30.588	30.489	30.854	30.008	30.201	30.196
21,	30.225	30.394	30.303	30.304	30.618	30.462	30.433	30.504	29.957	29.944	30.312	30.064
22,	30.353	30.186	30.186	30.284	30.479	30.615	30.572	30.555	30.307	30.537	30.530	30.558
23,	30.116	30.097	29.871	30.028	30.672	30.559	30.609	30.613	30.546	30.383	30.312	30.400
24,	30 044	30.123	30.248	30.138	30.558	30.363	30.502	30.474	30.403	30.243	30.220	30.180
25,	30.301	30.323	30 362	30.328	30.331	30.187	30.199	30.222	30.198	30.186	30.187	30.190
26,	30.372	30.165	30.321	30.286	29.872	30.172	29.743	29.929	30.220	30.219	29.906	30.114
27,	30.247	29.899	30.028	30.058	29.754	29.731	30.073	29.853	29.742	29.762	29.892	29.799
28,	30.072	29.965	29.897	29.977	29.983	29.884	29.871	29.896	30.176	30.110	30.278	30.188
29,	30.014	29.970	30.056	30.013	29.890	29.706	29.875	29.824	30.582	30.414	30.511	30.502
30,	30.222	30.295	30.377	30.298	29.977	29.956	29.986	29.973	30.646	30.302	30.174	30.374
31,	30.365	30.169	30.302	30.278	. . . .	. . . .	. . . .	. . . .	30.131	30.018	30.168	30.106
Means,	30.087	29.983	30.331	29.684	30.208	30.151	30.197	30.183	30.125	30.092	30.118	30.11

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Meteorological Records for 1888. Temperature.

Date.	January.							February.						
	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.
1,	36	43	38	38 8	44	21	23	26	31.5	29	28 9	33	23	10
2,	24.5	25 5	20	22.5	33	17 5	20.5	26	36.5	28	29.6	38	22 5	15 5
3,	21	29 5	28	25 6	31	17	14	17 5	38	28	27.9	39	13	26
4,	22	31	37	31.8	38	18.5	19.5	30	35	35	33.5	36	25	11
5,	30	35 5	23	27 9	37	20	17	32	37 5	33	33.9	38 5	31	7 5
6,	23 5	29.7	32 5	29 5	33	17	16	22	30	25	25.5	32.0	18	14
7,	35	46	41	40 8	47	26 5	20 5	28	32.5	31	30 6	33	22	11
8,	38	37	32	34 7	42	17	25	34 5	30	10	21.5	35	8	27
9,	26 5	27 8	29	23 3	32	24	8	8	14	. .	5.5	15	−5	20
10,	30 5	30 7	24	27 3	31	21	10	−5	12	10 5	7 0	14	−13	27
11,	11 5	15	7	10.1	24	3 5	20.5	11	22 5	20	18.4	23	8	15
12,	−1	18	17	12 8	20	−3 0	23	15	27 5	25	23 1	28	4	24
13,	23	32	36	30 8	37	12	25	30	43	36	36 2	45	21	24
14,	21	31	29	27.5	36	16	20	31.5	54	40	41 4	56	25	31
15,	34 5	38	20	28 1	39	18 5	22.5	9 5	13	2	6.6	41	- 0.5	40.5
16,	10	18	14	14 0	20	6	14	2.5	24	31 5	22.4	33	−6	39
17,	14	20 7	24	20.7	24 5	8	16 5	33	42	37	37.2	43 5	27	16.5
18,	17	20 5	14	16 4	28 0	12	14	39	39	34	38 5	40	26 5	13 5
19,	11 5	16 5	11	12 5	17	8	9	29	44.5	40	38 4	46	25	21
20,	20	22 5	12	16 6	24	8	16	42	48	41	43.0	50	36	14
21,	8 5	12	2.5	6 4	13	.	13	34.5	43	38	33 4	44	31	13
22,	−1 5	7	5	3.9	9	−8.5	17 5	36	45.5	31	35 9	47	28 5	18 5
23,	−1 5	9.5	17	1 .5	18.5	−9.0	27.5	24 5	41	35	33 9	42	21	23
24,	15	18 5	11	13 9	26	8	18	29	39	37	35 5	40	20	20
25,	11	19	15	15.0	21	3	18	34	43	39	38 8	44	31	13
26,	18.5	22	15	17 6	23	11	12	31	32	25	28.2	34	22	12
27,	13 5	15	5	9.6	16	−0 5	16 5	15	20	8	12 8	23	5	18
28,	2	11	12 5	9.2	13	−2	15	4.5	19	17	14 4	19	−1	20
29,	12	22	17	17.0	24	2	22	23	34	32 5	30.5	35	11	24
30,	21	28	28 5	26 5	28 5	3	25.5	. . . .	. . .	. .	. . . . .	. . . . .	.	. . . . .
31,	26	31	28.5	28 5	32	22	10	. . . . .	. . . . .	. . . . .	. . .	. . . . .	. . . .	. . . . .
Means,	18.5	24.6	20.8	21 1	27.9	10.2	17 7	24.24	33 48	26 81	28.46	36.10	16.62	19 38

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Meteorological Records for 1888. Temperature—CONTINUED.

DATE.	MARCH.							APRIL						
	7 A M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.	7 A M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.
1,	33	39	33	34 5	40	24	16	42	48	50	47 5	51 5	30 5	21 0
2,	34 5	38	38 5	37 5	39	24	15	45	60	40	48 5	61 5	38.0	23.5
3,	29.5	30	19	24 4	38.5	16	22 5	38	48	42	42 5	50	29	21
4,	10	27	18	18 2	29	4	25	40	58.5	46	47 6	61	29	32
5,	11	13.5	12	14 6	16	4	12	48	51	52	50 8	53 5	37 5	16 0
6,	12	20 5	22	19.1	22 5	7	15 5	51	56	45	49 2	57	42	15
7,	25	29	24	25.5	32	14	18	46	52.5	32.5	40 9	53	30 5	22 5
8,	27	36	25 5	28.5	37	14	23	28	44	38	37 0	45	20.5	24 5
9,	24 5	37 5	29	30	40	16	24	38	54 5	46	46 1	56	26	30
10,	28	46	36	37.5	48	22	26	42	47	50	47 2	51 5	39	12.5
11,	35	33	23 5	30	39	21	18	42 5	48	45	45.1	51 0	40	11 0
12,	15	16.5	9 5	12 6	18	6	12	41	49	30	37 5	51.0	28	23 0
13,	3 5	13	6	7 1	14	—1.5	15 5	30	45.5	42 5	40.1	49 0	20	29 0
14,	12	29	27	23.8	30 5	2 5	28	41 5	42	37	39 4	44 0	35	9 0
15,	22 5	32	34	30 6	35	13	12	38	50	43	43 5	53.0	33	20.0
16,	40	43	34	37 8	45	22	23	34	43.5	35	39 6	50	30	20.0
17,	30	37	28	29.8	39	23	16	42	48 5	43	44 1	49	26	23 0
18,	26	36.5	29	30 1	38	12	26	45	51	41	44 5	52 5	38 5	14 0
19,	32	49	46	43.2	52	19.5	32 5	43	54 5	43	45.9	55	33	22.0
20,	46.5	54	54 5	52 4	56	32 5	23 5	36	40 5	34	36 1	42	31.5	10 5
21,	51	43	33.5	40 2	55	31	24	39	39	33	36 0	40	29	11 0
22,	27	24	11	18.2	33 5	8	25 5	38	50	43	43 5	52.5	27	25 5
23,	12	19	15	15 2	20	5.5	14 5	35	44.5	37	38 4	45	31	14 0
24,	12	32	25	23 5	34	7	27	37 5	47	34	38 1	48.5	27	21 5
25,	18	27	24	23.2	28	12	16	42	51 5	46	46 9	53	23	30 0
26,	29.5	36	35	33 9	37	11	26	47	70	59	58 8	73	38	35 0
27,	34 5	45	41	40 4	47	20	27	58	75 5	61	63 9	78	44	34 0
28,	40	34 5	49.5	48.4	56	27 5	28.5	56	81	70	69 2	83	46	37 0
29,	36 5	41	34	36.4	49 5	32	17 5	72	83.5	68 5	73 4	85	55.5	29 5
30,	45	56.5	55	52 4	58	34	24	62 5	83	62	67 4	85	54	31 0
31,	51.5	55 5	41	47 2	58	39	19	. . .	. .	. .	. .	.	. .	. . . . .
Means,	28 5	33 4	29 6	30 5	38 2	17 8	20 4	43 26	54 06	41.71	46 89	55 98	33.71	22.27

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Meteorological Records for 1888. Temperature—Continued.

Date.	May.							June.						
	7 A. M.	2 P. M	9 P. M.	Mean.	Maximum.	Minimum	Range.	7 A. M.	2 P. M.	9 P. M.	Mean	Maximum.	Minimum.	Range.
1,	54	52 5	42 5	47 9	62	40 5	21.5	59	64	54	57.7	69	50	19
2,	39	49	42.5	43.2	50 5	36	14.5	53	53	48	50 6	56	46	10
3,	37 5	59	52	50 1	60	30.5	29 5	55.5	62	54	56 4	66	39 5	26.5
4,	53	65 5	54	56 6	67	42	25 0	61	70	58	61.8	73 5	38 5	35.0
5,	57.5	61	55	57 1	64	51	13 0	65	78	68	69 8	79	45 5	33 5
6,	60	71	61	63 2	73.5	41	32.5	72	85	71	74 8	86.5	58	28 5
7,	53 5	68 5	55	58 0	73.0	44	29.0	56 5	59	55 5	56 6	60 0	52	8 0
8,	52	55 5	53	53 4	58.5	47	11 5	56.5	73	65	64.9	78	50	28 0
9,	54.5	74.5	60	64 8	76.0	50 5	25.5	72 5	80	71	73 6	81	55	26 0
10,	62	77	63	68.2	78 5	55	23 5	70	81	75	75 2	84	65	19 0
11,	66	64	61	63 0	67 0	60	7.0	65	59.5	54	58.1	75	52	23 0
12,	63	64	57	66.2	66	55	11.0	63	71	59	63 0	73	42	31.0
13,	56	65	52	56 2	67 5	43	24 5	67 5	73 5	66	68 2	76	47	29 0
14,	54	52	46	49.5	55	41	14 0	67	83	63	70 0	74	55	29 0
15,	41	47	43	43 5	50	35 5	14.5	74	85 5	72	75 9	87	62	25.0
16,	44	55.5	42	44.6	55	39	16 0	83 5	83 5	72	77.7	87	68	19 0
17,	52.5	53.5	53	54.2	60	33	27.0	79	86	73	77.7	88	60	28.0
18,	46	52	53.5	51 2	54	41	13 0	82	91	73	79 5	93	62	31.0
19,	55	58	46	51 2	60	41 5	18 5	69	83	72	74	86	60	26 0
20,	50	61	52	52.8	63	38	25 0	59	88	78	80 7	89	60	29 0
21,	55	64	57	58 2	67	45	22.0	79	94	71	78 7	95	64	31 0
22,	54	65	58	58 8	67	43	24.0	79 5	87	77	80 1	88	77	11 0
23,	52	61.5	56 5	56.6	62	47.5	14 5	85.5	76	69	74 9	87	67	20.0
24,	55	58.5	57.5	57 1	60	51.5	8 5	72	82	69	73	84	65	19 0
25,	56	61 5	58	58.4	63	53	10 0	77	81	71	75	85	69	16 0
26,	57 5	64	59	59 9	65 5	53 5	12.0	70	77	64	68 8	79	60	19 0
27,	65	78 5	68.5	70.1	80	48.5	31 5	63	74	63	65.7	76	54	22.0
28,	66 5	80 5	65	69 2	82	60 5	21 5	59	62	57	58 2	66	55	11 0
29,	66	73	67	69.5	78	60.5	17.5	53	57	58	56 5	60	50	10 0
30,	65	74	64	66.7	76	59	17.0	58 5	75	68	67 4	68	56	12 0
31,	64	67	60	62 7	70	59	11 0	.....	.	.....	.....	..	.....	
Means,	55.0	63 16	55 27	57.57	65 22	46 63	18 59	68 22	75 77	65.68	68 83	78 63	56.15	22 48

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Meteorological Records for 1888. Temperature—CONTINUED.

DATE.	JULY.							AUGUST.						
	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.
1,	63	67	60	62.2	68	50	18 0	70	81	70	72 7	83	59	24 0
2,	65 5	70	62	64.8	71	60	11 0	67	80	69	71.2	80	53	27 0
3,	63	79	67	69	80	51	29.0	76	85	75	77 7	84	55	29 0
4,	75	85	72	76	86	58	28.0	81	90	71	78 2	92 0	63	29 0
5,	71	82	75	75 5	85	65	20 0	74	79	74	75 2	82	61	21 0
6,	73 5	83	70 5	74 3	85	59	26 0	74	85	78	78 7	87	69	18.0
7,	76	81	71.5	75 0	82	61	21.0	80	85	73	77.7	87	64	23 0
8,	71	...	72	71.6	74	55	19 0	79	90	74	79.2	91	63	28 0
9,	68	65	63	64 7	69	60	9.0	75	79	65	71.3	81	63	18.0
10,	61	77	61	68 5	78	58	20 0	65	73	67	68 5	77	50	27 0
11,	72.5	83	76	76 3	85	68	17 0	80	78	66	67 5	79	55	24 0
12,	69	59	53	58 5	69	51	18.0	66	70	61	64 5	71	55	16 0
13,	54	68	61	61	69	45	24 0	59	67	58	60.5	69	53	16 0
14,	64	75	68	68 7	70	51	19 0	68	74	66	68 5	74 5	49	25 5
15,	62 5	74	64	66 1	78	59	19 0	61	81.25	72	71 56	82	56	26 0
16,	57.5	75	65	65.6	76	50	26 0	81	85	77	80	87	70	17 0
17,	66	75	67	68.7	77	51	26 0	69	77 5	73	73 6	79	67	12 0
18,	65	68	66	66 2	69	61	8.0	72	77	67	70 7	79	65	14.0
19,	66 5	75	62	66.3	76	49	27 0	73	77	68	71.5	78	54	24 0
20,	63	74	65	66.7	76	57	19 0	65	77	70	70 5	80	59	21 0
21,	66	76	65	69	77	53	24 0	60.5	61	61	60.8	62	59	3 0
22,	73	79	63	72	80	56	24 0	58	61	53	56 2	65	45	20.0
23,	75	82	69	73 9	84	53	31 0	59	69	58	60.7	69	43	26 0
24,	74	80	66	71 5	82	54	28.0	67	76	64	67 7	77	59	18 0
25,	68	80	67	70.5	81	50	31 0	70	78.5	68.5	71 3	81	58	23 0
26,	71	81	66	71	83	53	30.0	69	88	72	76 5	84	60	24.0
27,	64	74	64	68 5	76	60	16 0	72	75	60	66 7	76	54	22.0
28,	63	...	63	63	74	55	19.0	60	67	55	59.2	67.5	45	22 5
29,	70	79	67	70 7	80	54	26.0	63	75	63	66	76	49	27 0
30,	64	80	70	71	82	58	24.0	61	79	69	69 5	82	50	32 0
31,	73	86	71	78 2	88	60	28.0	60	67	62	62.7	68	51	17.0
Means,	67.8	71	66 5	69 2	78 0	55.1	22.9	68 4	76 8	70.6	69 9	78 3	56.6	21.7

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Meteorological Records for 1888. Temperature—Continued.

Date.	September.							October.						
	7 A. M.	2 P. M.	9 P M.	Mean.	Maximum.	Minimum.	Range.	7 A. M.	2 P. M.	9 P M.	Mean.	Maximum.	Minimum.	Range.
1,	65	70	68	65 2	73	57	16 0	45	66	55-	55 2	67	38	29
2,	65	70	58	62.5	72	50	22.0	48	47	38	42.7	48	36	12
3,	52	68	62	61	69	48	21.0	39	44	35	38.2	45	30	15
4,	58	72	65	65	73	53	20 0	39	55	46	46 5	56	33	23
5,	63	64	55	59.2	65	42	23 0	43	61	55	53.5	62	36	26
6,	47	60	51	52 2	61	40	21.0	51	55	50	53	57	36	21
7,	48	51	52	50 7	52	35	17.0	46	54	46	48	54	38	16
8,	53	64	62.5	6 .5	65	43	22.0	46	49	36	41.7	49	34	15
9,	63 5	76	67	68 4	77	55	22.0	34	46	40	42 5	47	32	15
10,	60	68	59	6 .5	69 5	52	17 5	40	59	48	48 7	59	30	29
11,	55	67	61	61	69	50	19 0	35	43	42	43.3	44	31	13
12,	64 5	69	65	65 8	70	50	20.0	40.5	45	42	42.3	45	30	25
13,	57	60	50	54 2	62	47	15 0	. . .	. . .	. . .	42	44	31	13
14,	51	61	54	55	71	38	33 0	44	47	41	45.7	48	40	8
15,	46	64	61	58	65	40	25 0	35	52	47	45 2	52	30	22
16,	62	67	64	64 2	68	49	19 0	48	57	46	49 2	58	14	44
17,	58	62	61	60 5	62	53	9 0	42 5	53	46	47 1	54	41	13
18,	63	72	63	65.2	74	53	21 0	45.5	52	44	46 3	53	40	13
19,	58	73	63	64 2	74	54	20 0	45	55	51	50 5	56	37	19
20,	59	67	61	62	68	52	16 0	44	42	37	40	52	34	18
21,	63	64	54	53.7	66	49	17.0	36	39	37	37.2	41	33	8
22,	59	67	58	60 3	69	44	25.0	31	49	43	41.5	49	29	20
23,	60	68	60	62	68	55	13 0	41	50	43	44 2	52	29	23
24,	48	62	53	54	64	43	21 0	44	48	41	43 5	56	38	18
25,	46	54	48	49	61	43	18 0	42	61	45	43 2	62	35	27
26,	53	54	52 5	53	56	40	16 0	47	52	43	46 2	53	41	12
27,	51	62 5	50	53 3	63	46	17.0	47	53	53	49	54	48	6
28,	51	53	37	44 5	54	43	11 0	50	47	42	45 2	50	38	12
29,	40	47	36	37.2	48	34	14 0	41	49	43	44	50	37	13
30,	42	46	42	43	47	32	15.0	38	49	40	41.7	51	33	18
31,	. . .	. . .	. . .	. . .	. . .	. . .	. .	45	62	53	53 2	63	34	29
Means,	55 37	60 08	56.20	57.71	65.18	46 33	18 85	42 5	51.3	40 8	45 5	53.2	35.1	18 1

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Meteorological Records for 1888. Temperature—CONTINUED.

DATE.	NOVEMBER.							DECEMBER.						
	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Maximum.	Minimum.	Range.
1,	45.5	70	60	58 8	70	40	30	32 5	33	32	33.1	37	29	8
2,	55	70	63.5	55 5	72	45	27	30	37	31	33	37	26	11
3,	57	55	43	49 5	63	40	23	29	30	29	29.2	35	24	11
4,	41	58	52	50 7	60	35	25	29	28	34	31 2	35	25	10
5,	50	65	59	58 2	65	44	21	37	47	39	40.5	47	30	17
6,	59	70	57	60 7	72	55	17	28	30	29	29 0	32	23	9
7,	42	51	41	44.5	52	38	14	26.5	45	39	37 3	45	26	19
8,	44	44.5	48 5	43 3	44	37	7	37	43	35	37.5	44	25	19
9,	56	65	65	62 7	65	43	22	34	38 5	37	38.3	40	30	10
10,	66	67	44	55 2	68	40	28	36	37.5	35	35.8	42	32	10
11,	37	40	35	30.7	42	32	10	32.5	36	33	33 8	38	30	6
12,	36	49	41	41 7	48	31	17	27	29	25	26.5	31	22	9
13,	33	50	44	42.7	35	29	6	24	27	18	21 7	28	12	16
14,	34	55	48	43 7	57	29	28	12	21.5	17	16.8	24	12	12
15,	42	49	45	45.2	51	39	12	11	35	33	28	37	11	26
16,	50	42	32	39	44	32	12	32	45	44	41.2	46	15	31
17,	28	38	31	31	35	22	13	43	42 5	43	42.8	46	23	23
18,	25 5	34	34	31.8	35	21	14	30	27	24 5	26 5	28	20	8
19,	34	39	40	38 2	42	29	13	19 5	25	12	17.1	27	12	15
20,	31 5	39	28	31.3	41	24	17	21	23	19	20 5	25	12	13
21,	18	31	24.5	24 5	32	13	19	24	27	12	18 7	28	7	21
22,	18	32	24	24 5	32	12	20	7	24	20	17 7	25	1	24
23,	16 5	50 5	26	44 7	31	12	19	11	44	37	32.2	45	6	39
24,	23	44	28	30.7	44	21	23	25	51	41 5	39 7	52	17	35
25,	24 5	35	28	27 8	37	23	14	41	55	49	48 5	57	32	25
26,	24	28	29	27 5	29	15	14	40	52	51	48 5	52	17	35
27,	31.5	35	34	33.8	38	19	19	47	33 5	30 5	42.8	34	26	8
28,	33 5	36	34	34 3	47	25	22	29	32	29.5	30	32	24	8
29,	34	36	36	35 5	40	25	15	25 3	35 5	25	27.5	36	22	14
30,	36	38	35	36	39	30	9	23	43	41	37	44	19	25
31,	.....	.....	.....	.....	.....	.....	.....	38.5	41.5	36	35.7	42	28	14
Means,	37 50	46 37	40 25	41.16	48.13	30	18 13	28.45	36 03	31 71	32 20	37 71	20.58	17.13

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Meteorological Records for 1888. Dew Points (in Degrees Fahrenheit).

Dates.	January.				February.				March.			
	7 A. M.	2 . M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	24 5	41	30	35 2	24.5	25 5	26	25 3	30	36	31 5	32 5
2,	19 5	24	18	20.5	23	29.5	25	25 8	33	38	37	36 0
3,	18 5	28	21 5	29 3	15 5	33	25	24 5	25	24	13	20.7
4,	20 5	29 5	32	27 3	30	33	32	31.3	7 5	19	11 5	12 7
5,	27	31	19	28	29	34.5	27	30 2	8 5	11	9	9 5
6,	22	29	31	27 3	20 5	27	18	21 8	9	14 5	19	14 2
7,	35	45	40	40	25	29 5	28	27 5	22	24 5	17	21 2
8,	36 5	34	29	33 2	33	27	7.5	22 5	24	30	19	24 3
9,	23 5	24.8	29	25 8	2	9	- 4	2 3	17 5	25.5	26	23 0
10,	30 5	29 7	17	25 7	- 9	9	8	2 7	25	33	31 5	31 8
11,	8 8	6	7	7 2	8 5	20 5	18	15 7	32	36 5	20 5	29 7
12,	-1	14	13	8 7	13	24 5	23 5	20 3	11	10	4	8 3
13,	21 5	29	30	26 8	28 5	36 5	30	31 7	-3 5	10.5	3	3 3
14,	17	23 5	26	23 2	25 5	39 5	37	34 0	9	20	22 5	10.5
15,	34 5	34	12	26.8	4	2	-1 5	1 5	21	27	29.5	26 8
16,	7.5	11 5	6 5	8 5	-1	17	23 5	14 8	35	38	28	33 7
17,	11 5	18.7	22.5	17 6	24	28	32	28 0	22 5	27	20	23 2
18,	15	9	9	11 0	32 5	32 5	28	31 0	23	28	28	25 7
19,	9	10	8 5	9 2	20	36	32	29 3	29	40	40	36 3
20,	12	17 5	9 5	13 0	40	44	36	40 0	42	48	50 5	46 8
21,	5.5	4	-1.5	2 7	26	31 5	30	29 2	49	35	27.5	37 2
22,	-3 5	4	2	.83	28 5	34.5	28	30 3	21	17	6	14 7
23,	-3 5	8	15	6 5	21 5	33	32	28 8	7	5	11	7 7
24,	13	10	6	9 7	26	34	29	29 7	7	26	15	16 0
25,	8 5	18	13	11 5	32 5	39.5	35	35 7	14	24	22 5	20 2
26,	14 5	15	11	13.5	28 5	23	22	23 8	28	23	33 5	31 5
27,	8.5	6	- 1	4 5	13	16	2	10.3	34.5	40	41	38 5
28,	- 1 5	3	9 7	9 7	1 2	17	13	10 4	40	46 5	43 5	45 0
29,	9	10	15	11 8	20	27	31	26.0	32 2	31 5	31	31 6
30,	19	26 5	27	24 2	.....	.....	.....	.....	36 5	41 5	40	39 3
31,	24 5	29	27	26 8	...	.....	...	.....	36	41 2	36	37 7
Means,	16 0	19 9	17 0	18 14	21 12	26 63	25.39	23 99	23.1	29.9	24 8	25 44

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Meteorological Records for 1888. Dew Points—CONTINUED.

DATES.	APRIL.				MAY.				JUNE.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	31	30	39 5	33 5	46	40.2	37 5	41 6	49	38	43	43 3
2,	41.5	33	30 5	35.7	31	34	33.2	32.7	47	49	41	45 7
3,	30	24	25	26 3	32 5	42	43	39.2	46 5	46	43	45 2
4,	30 5	32	33	31 8	44	49 5	52	48 5	47	52	50	50
5,	42 5	49	51	47.5	48 5	46	47	47 2	53	55	57	55
6,	43 5	28	29	33 5	50	48	49	49 0	60	68	65 5	64 5
7,	30	27.8	28 5	27 1	43 7	58.5	42	44.7	49.5	50	50 5	50.0
8,	22	24	30	25 3	43	45.5	51	46.5	49 5	58	58	55.2
9,	21	35 5	36	30 8	53.5	64.5	59	59 0	61.5	66	63	63 5
10,	40	44	47	43 7	60	64	60	61 3	63	70	64	65 7
11,	33 7	36	35	34 9	59	61	59	59 7	62	50 5	47	53.2
12,	30	24	19	27 3	61	61	53	58 3	52	53	51	52 0
13,	22 5	27 7	30 5	26 9	46	39	41	42.0	53	59.5	59	57.2
14,	38	32.5	29	33 2	43	41	36	40 0	64	64	62	63 3
15,	30	34 5	38	34 2	33	35	38	35 3	66	65 5	67	66 2
16,	34	28 7	24 5	29 2	42	39 7	28	36 6	71 5	62.5	66	66 7
17,	31	30 5	33	31 5	37 5	35.5	44	39 0	63	63	65	63 3
18,	36 5	40	30	35 5	42.5	50	52 5	48 7	67	67	63	62 3
19,	38	34	41	37 7	47	39	36	40.7	56	58	62	58 7
20,	29.5	29	27	28 5	38	45	41	41 3	63	66	62	63 7
21,	26	24	24	34 7	42 5	46	43 5	44 0	68	72	68	69 3
22,	26	31	35	30.7	47	39	43	43 0	71 5	75	71	72 5
23,	28 5	28	29	28 5	44 5	50	54 5	49 7	75	71	66	70 7
24,	27 5	23	26	25 5	53	56 5	56 5	55 3	69	70	67	68.7
25,	23	26	33	27.3	54	55 5	55	54 8	64	61	66	63 7
26,	33 5	42 5	42	39 3	54 5	59	55	56 2	68	62	61	63 7
27,	46	49 5	45	46.8	58	62 5	63 5	61 0	56	64	60	60 0
28	44 5	55	52	50 5	63.5	70 5	62	65 3	55	57	53	55 0
29,	56	49	54 5	53 2	59	72	62	64 3	49	53	56	52 7
20,	49 7	56	53	52 9	60	61	61	60 7	58	62	59	59.0
31,	. .		. .	. .	59	62	54	58 3		. . .	. .	. .
Means,	34 16	34.40	34 33	34 81	48 2	50 3	48.75	34.81	59 17	60 23	58 53	59 33

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Meteorological Records for 1888. Dew Points—Continued.

Dates.	July.				August.				September.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M	Mean.
1,	52	52	50	51 3	68	63	56	62 3	62	63	60	61 7
2,	56	52	55	54.3	58	62	61	60 3	53	52	54	53 0
3,	56	64	60	60 0	61	70	67	66 0	50	56	57	54 3
4,	64	68	69	67.0	72	76	68	72 0	56	64	62	60 7
5,	68	73	64	63 3	69	78	73	71 7	54	55	51	53 3
6,	60	74	63	65.7	69	73	72	71 3	43	46	43	43 3
7,	70	70	53.5	64 5	71	68	67	65.3	44	45	50	46 3
8,	58	. .	60	39.3	68	74	69	70 3	53	62	62 5	59 2
9,	65	63	63	63 5	65	59	58	60 7	63 5	68	64	65 2
10,	61	63	68	68 3	54	54	58	55 3	56	54	57	55 7
11,	62.5	66	55	64 5	54	65	64	61 0	53	52	56	53 3
12,	45	51	51	49 0	64	63	59	62 0	57	66	63	62 0
13,	48	53	47	49 3	51	52	52	51 7	51	56	46	51 0
14,	55	60	58	57 7	56	55	57	56 0	45	59	48	50 7
15,	57	52	55	54 7	57	67	64	62 7	46	57	56	53 0
16,	54	58	58	56 7	70	81	69	73.3	58	65	64	62 3
17,	57	60	54	57 0	67	71	70	69 3	58	60	61	59 6
18,	56	63	64	61 0	66	68	62	65 3	58	62	58	59 3
19,	66 5	67	60	64 5	61	64	65	63 3	52	60	53	56.6
20,	60	64	58	60 7	62	62	63	62.3	55	60	61	58 6
21,	59	59	58	58 7	60	59	59	66 0	56	53	48	52 3
22,	60	59	59	59 7	52	47	44	47 7	53	56	54	54 3
23,	65	66	62	64.3	49	47	52	49 3	52	56	56	54 6
24,	64	62	58	59 7	52	53	57	54 0	48	53	51	50 8
25,	58	63	60	60 3	65	60	59	61 3	46	50	48	48 0
26,	59	63	62	61.3	61	66	66	64.3	49	50	51	50 0
27,	61	61	62	61 3	67	60	48	58.7	47	48	43	46 0
28,	58	.	63	40 3	50	50	53	51.0	45	42	37	41 3
29,	62	65	60	62 3	52	58	54	54 7	37	32	33	34 0
30,	61	68	65	64 7	59	63	59	60 3	35	41	35	37 0
31,	67	69	68	68 0	56	65	58	59 7	. .	. . . .	. . .	. .
Means,	59 5	58 0	59 6	59 12	61.1	62 8	60 7	61 58	51.18	54 77	52.88	52.90

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Meteorological Records for 1888. Dew Points—CONTINUED.

DATES.	OCTOBER.				NOVEMBER.				DECEMBER.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	42	53	53	49 7	43	52	48	47 7	29	27	29	28 3
2,	44	43	35	40 7	45	56	58	53 0	24	34	28	28.7
3,	34	31	32	32 3	55	45	35	45 0	29	30	29	29 3
4,	31	37	41	36.3	39	46	43	42.7	29	28	34	30 3
5,	41	52	51	48 0	41	45	55	47	29	37	38	34
6,	51	55	46	50 7	53	62	53	56	25	24	29	26
7,	41	43	44	42 7	37	38	39	98	26 5	35	31	30 8
8,	41	42	30	37 7	37	33	46	40 3	29	35	32	32
9,	28	41	22	30 3	50	60	63	57 7	31	35	34	33 3
10,	22	55	46	41 0	63	64	37	54 7	30	34	32	32
11,	33	31	37	33 7	22	29	29	30	32	30	30	30 7
12,	40 5	40	37	39 2	30	28	30	29.7	24	26	25	25
13,	..	.	40	13 3	30	41	34	35	21	21	18	20
14,	42	43	44	43.0	28	39	39	35.3	12	21 5	17	16 3
15,	35	43	43	40 3	40	47	43	43 3	11	35	33	26 3
16,	46	53	44	47 7	43	37	32	97.3	32	35	44	37
17,	41	47	41	43 0	22	30	31	27 7	43	42 5	41	42 2
18,	42	41	42	41 7	25 5	34	34	31 2	24	24	24	24
19,	43	47	42	44 0	34	36	35	35	19.5	22	12	17.8
20,	37	31	32	33 3	25	24	22	23 7	17	20	19	18 7
21,	27	31	32	30 0	18	25	24	22 3	24	21	7	17.3
22,	28	37	38	34 3	18	29	21	22.7	7	17	16	13 3
23,	41	46	43	43 3	16 5	30	26	24 2	11	39	25	25
24,	39	39	36	38.0	23	42	28	31	25	42	39	35 3
25,	37	47	35	49 7	24.5	32	26	27 5	19	43	43	35
26,	43	35	38	38 7	21	28	29	26	40	46	47	44 3
27,	43	49	49	47 0	31 5	32	31	31.5	47	30	23	31 7
28,	48	40	31	39 7	33 5	33	31	32.5	29	32	29 5	30 2
29,	33	37	35	35 0	31	33	33	32 3	24 5	35	25	28 2
30,	30	31	32	31 0	32	33	32	32 3	28	35	33	30.3
31,	32	46	44	40 7	..	.....	.....	.....	38 5	41 5	33	37 7
Means,	37.5	42.2	39 6	41 16	34 05	38 93	36 23	40.45	25.9	31.47	29 08	28 80

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Meteorological Records for 1888. Percentage of Atmospheric Humidity.

Dates.	January.				February.				March.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	94	93	72	86 3	94	78	88	86.7	88	89	94	90 3
2,	80	94	91	88 3	85	75	88	81.7	94	100	94	96.0
3,	89	94	82	88.3	91	82	88	87.0	82	77	76	78 3
4,	94	94	82	90 0	100	89	89	92.7	89	70	78	78.0
5,	88	83	84	85.0	88	89	78	85.0	89	89	87	88.3
6,	94	97	94	96 0	94	88	73	85.0	87	76	87	83 3
7,	100	93	96	97 3	88	88	88	88 0	88	82	73	81 0
8,	94	89	88	90 3	94	88	89	90.3	88	79	75	80 7
9,	88	88	100	92 0	76	80	83	79 7	73	61	86	74 0
10,	100	96	73	89 7	53	87	89	86 3	88	76	77	80 3
11,	87	67	100	84 7	89	92	91	90 7	89	94	88	90 3
12,	100	84	83	89 0	91	88	94	91 0	83	75	78	78 7
13,	94	88	79	87 0	94	78	79	83 7	72	89	87	82 7
14,	84	72	88	81 3	78	58	89	75 0	87	64	82	77 7
15,	100	85	70	85.0	78	61	85	74 7	94	81	83	86 0
16,	89	75	72	78 7	85	73	88	82 0	82	83	78	81.0
17,	94	91	94	93 0	68	58	83	69.3	72	66	76	71 3
18,	91	76	80	82.3	77	78	78	77.7	88	71	83	82.3
19,	89	75	89	84 3	88	73	73	7 . 0	88	71	80	79.7
20,	70	90	89	79.7	93	86	82	87 0	85	77	86	82 7
21,	87	70	83	80.0	70	64	72	68 7	93	74	78	81.7
22,	79	87	87	84.3	74	65	88	75.7	77	73	80	76 7
23,	79	89	91	86 3	83	73	89	83 3	80	53	83	72.0
24,	89	69	80	79 3	88	82	72	80.7	80	78	64	74 0
25,	89	76	91	85 3	94	88	86	89 3	83	88	94	88 3
26,	84	73	83	80 0	88	66	88	79 7	94	89	94	92 3
27,	80	67	76	74 3	91	84	76	83.7	100	83	100	94 3
28,	85	70	88	81 0	86	91	83	86.7	100	74	98	90 0
29,	87	58	91	78 7	88	74	94	85 3	85	68	89	80 7
30,	91	94	94	93 0	. . . .	. . . .	. . . .	. . . .	72	57	57	62 0
31,	94	92	94	93 3	. . . .	. . . .	. . . .	. . . .	56	60	82	66.0
Means,	89.10	82.60	85.90	85.90	86 13	78.89	84 20	84.95	86 00	75.70	79 90	81 40

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Meteorological Records for 1888. Percentage of Atmospheric Humidity—CONTINUED.

DATES.	APRIL.				MAY.				JUNE.			
	7 A. M.	2 P. M.	9 P M	Mean	7 A. M.	P. M.	9 P. M	Mean.	7 A. M.	2 P. M.	9 P M.	Mean.
1,	65	50	67	60.7	74	64	82	73 3	69	39	66	54 7
2,	88	44	69	67 0	73	56	71	66.7	90	86	77	81.0
3,	72	38	50	53 3	82	54	72	69 3	72	56	66	64 7
4,	69	37	60	55.3	72	56	93	73 7	69	53	74	62 3
5,	81	93	96	90.0	72	58	74	68	65	46	68	59 7
6,	74	34	53	53 7	70	44	65	59.7	63	57	83	68 7
7,	53	38	68	53 0	69	49	62	60	77	72	83	77 3
8,	77	45	72	64 7	72	68	93	77 7	77	59	78	71 3
9,	49	48	68	55.3	96	71	96	87 7	68	62	76	68 7
10,	92	89	90	90 3	93	64	90	82 3	79	69	69	72 3
11,	69	63	68	66.7	78	90	93	87 0	90	72	77	79.7
12,	92	37	62	63.7	93	90	86	89 7	68	53	75	65.3
13,	72	74	62	69 3	69	39	66	58 0	80	62	78	66 7
14,	87	69	72	76.0	67	66	68	67 0	90	53	90	77.7
15,	72	56	83	70.3	73	63	83	73 0	76	51	84	70 3
16,	100	46	57	67 7	93	66	58	72 3	67	49	82	66 0
17,	65	50	68	61.0	57	42	72	57.0	58	44	76	59.3
18,	73	66	65	68.0	88	93	96	92.3	60	47	50	52.3
19,	33	68	93	81 3	74	49	68	63 7	63	43	71	56 7
20,	77	65	74	72 0	64	56	66	62.0	58	48	58	54 6
21,	59	54	68	60 3	63	52	61	58 7	69	49	90	69 3
22,	62	48	74	61 3	77	39	58	58 0	77	68	82	91 7
23,	77	52	72	67 0	76	66	93	78 3	72	86	90	82 3
24,	66	38	71	58.3	93	93	96	94 0	90	67	93	83 0
25,	47	37	60	48 0	93	81	90	88 0	64	51	84	66.3
26,	60	37	54	50 3	90	84	87	87 0	84	60	90	78 0
27,	64	41	56	53.7	78	58	81	72 3	78	71	90	79 0
28,	66	41	53	53 3	90	72	90	84.0	83	84	86	85 3
29,	57	31	61	49 7	78	82	84	81.0	86	86	93	88 3
30,	62	41	72	58.3	84	63	90	79 0	93	64	73	78.7
31,	....	....	.....	...	83	84	45	70.6	...	.....	...	...
Means,	71.00	51 03	67.83	63 31	79 10	64.90	80 93	73 91	73 40	60.20	78 40	70 64

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Meteorological Records for 1888. Percentage of Atmospheric Humidity—Continued.

Dates.	July.				August.				September.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	68	59	70	65 6	93	54	62	69 6	90	79	90	86
2,	73	53	78	68 0	73	54	78	67 6	63	79	87	76 3
3,	78	60	78	72 0	60	61	76	65 6	93	66	84	81
4,	69	70	90	76.3	74	64	90	78 0	93	76	90	86 3
5,	90	74	69	77 7	85	82	97	88 0	73	73	86	77 3
6,	64	74	78	72 0	85	67	82	78 0	86	60	72	72.6
7,	82	69	53	68 0	74	55	82	70.0	86	80	93	86.3
8,	64	. .	66	65 0	69	60	85	71 3	100	93	100	97 6
9,	90	93	100	94 3	71	48	78	65 6	100	76	90	88 3
10,	100	69	84	84 3	68	43	84	66 3	87	61	93	80 3
11,	71	57	69	65 6	81	65	93	79.6	93	59	84	78 6
12,	42	74	93	66 3	93	79	93	88 3	76	90	90	86 3
13,	80	59	60	66 3	75	84	81	80 0	83	86	56	84
14,	73	62	70	68 3	66	52	73	63 6	80	93	80	84 3
15,	84	47	73	68 0	87	88	76	83 6	100	78	84	86 3
16,	90	56	78	78 3	69	83	76	77.6	87	93	100	93.3
17,	73	60	63	65 3	93	82	90	88 3	100	93	100	97 6
18,	72	84	93	83.0	84	74	84	80 6	84	71	84	79 6
19,	100	74	93	89 0	66	64	90	78 6	81	64	84	76 3
20,	90	71	78	79 6	90	66	79	78 3	87	78	100	88 3
21,	78	56	78	70 6	100	93	93	95 3	78	68	80	75 3
22	64	50	73	62 3	80	60	72	70 6	81	68	86	78 3
23,	71	58	78	69 0	70	47	81	60.0	71	66	87	75 6
24,	70	57	63	63 3	59	45	78	60.6	100	72	93	88 3
25,	70	60	78	69 3	84	54	73	70 3	100	87	100	95 6
26,	68	57	87	70 0	76	79	82	79 0	86	86	96	89 3
27,	90	64	98	82.3	84	58	65	69.0	86	60	77	72 3
28,	84	. . .	93	88 5	70	55	93	72.6	80	66	100	82
29,	76	67	78	72 0	68	56	73	65.6	89	56	89	78
30,	90	67	84	80 0	93	58	70	77.0	76	83	76	78.3
31,	62	57	74	71.0	87	93	87	89.0	. . .	. .	. . . . .	. . . . .
Means,	74 0	59 0	77 0	73 3	78 2	65 5	84 3	73.2	85 3	75.3	87 7	83 32

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Meteorological Records for 1888. Percentage of Atmospheric Humidity—CONTINUED.

DATES.	OCTOBER.				NOVEMBER.				DECEMBER.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1,	93	63	93	83	93	53	65	70 3	88	85	68	87
2,	86	83	89	87	69	62	84	71 6	78	89	88	85
3,	82	65	89	78 6	93	69	74	78 6	100	110	100	100
4,	73	55	83	70.3	92	64	72	76.0	100	100	100	100
5,	92	72	86	83 3	72	68	87	73 6	72	68	89	76.3
6,	100	100	86	95 3	81	76	86	81	88	78	100	88.6
7,	83	66	93	80.6	82	61	62	68 3	100	68	73	80 3
8,	83	77	79	79.6	76	80	93	83	79	74	89	80 6
9,	79	83	48	66 6	80	84	93	85 6	89	89	89	89 0
10,	48	87	93	76 0	90	90	76	85 3	79	89	89	85.6
11,	92	63	82	79	82	65	79	75.3	100	79	88	89 0
12,	100	83	82	88.3	79	66	65	63 3	89	88	100	92 3
13,	. .	. . .	92	92	88	72	68	76	88	77	100	88 3
14,	93	86	93	90 6	78	55	71	68	100	100	100	100
15,	100	72	86	86	93	93	93	93	100	100	100	100
16,	93	86	93	90.6	77	82	100	86.3	100	68	100	89 3
17,	93	86	83	85.3	77	83	100	88 3	100	100	92	97 3
18,	89	66	93	82 6	100	100	100	100	78	86	100	88 6
19,	93	74	72	83	100	89	82	90 3	100	88	100	96.0
20,	76	35	82	74 3	78	54	77	39 6	84	84	100	90 6
21,	69	72	82	74.3	100	78	100	92 6	100	77	80	85 0
22,	83	61	83	77.3	100	88	88	92	100	73	84	85 6
23,	100	86	100	75 3	100	100	100	100	100	83	61	81 3
24,	83	71	83	79	100	93	100	97.6	100	74	92	88 0
25,	83	87	68	79 3	100	89	100	96 3	41	93	80	71 3
26,	86	77	85	82	87	100	100	95 6	100	80	86	84 6
27,	86	86	86	86	100	89	88	92	100	88	88	92 0
28,	93	77	65	75	100	89	88	92 3	100	100	100	100
29,	73	63	74	70	88	89	89	88 6	100	100	100	100
30,	72	74	73	73	85	82	89	85 3	100	74	73	82 3
31,	89	56	72	72 3	. .	. . .	. .	.	100	100	89	96 3
Means,	82.6	76 9	83.7	81.2	88.0	78 93	85 63	77 04	92 7	86 9	90.9	89.94

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Meteorological Records for 1888. Precipitation in Inches (Rain and Snow.)

Dates.	January.		February.		March.		April.		May.		June.	
	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.
1,	.57	00	.01	.25	.005	00	.03	....	.06	00	...	.00
2,	.00	....	00	00	.25	00	00	00	00	00	.30	.00
3,	.00	.25	00	00	00	00	00	00	00	00	.00	.00
4,	.00	00	.28	00	00	00	00	00	.25	00	00	.00
5,	.00	00	.65	.....	.04	.50	.46	00	.23	00	00	.00
6,	.20	1.50	00	00	00	00	.66	00	00	00	.07	.00
7,	.54	00	.19	2.00	00	.....	00	00	00	00	00	.00
8,	.32	00	.05	.50	00	00	00	00	.13	00	00	.00
9,	.00	..	00	00	00	00	00	00	.23	00	00	.00
10,	.13	1 00	...	....	00	00	.69	00	1 21	00	00	.00
11,	.00	00	.14	1.50	.32	8 00	00	00	.....	00	.20	.00
12,	.00	00	00	.....	00	00	.10	00	.44	00	.00	.00
13,	.63	6 50	00	00	.02	.25	00	00	00	00	.....	.00
14,	.00	.00	00	00	00	00	.12	.....	.08	00	....	.00
15,	.27	.00	00	00	00	00	00	....	00	00	.00	.00
16,	00	00	00	00	.10	00	.28	.25	.07	00	.00	.00
17,	.10	1.00	00	00	00	.....	00	00	00	00	.00	.00
18,	.01	....	00	00	00	00	.03	00	22	00	.00	.00
19,	00	00	00	00	00	00	.23	00	.80	00	.00	.00
20,	00	....	.49	00	.02	00	.21	00	00	00	.00	.00
21,	00	00	00	00	.77	00	00	.....	00	00	.60	.00
22,	00	00	00	00	00	....	00	00	00	00	.00	.00
23,	.01	.15	00	00	00	00	00	00	...	00	.62	.00
24,	00	00	00	00	00	00	00	00	.96	00	.00	.00
25,	.50	5 00	.48	00	...	...	00	00	.07	00	.04	.00
26,	00	00	.01	.15	.33	2.75	00	00	.20	00	.00	.00
27,	00	00	00	...	.02	00	00	00	00	00	.78	.00
28,	00	00	00	00	....	00	00	00	1.21	00	.00	.00
29,	.08	1 00	00	.....	.48	00	00	00	00	00	.00	.00
30,	.....	00	.....	.....	00	00	00	00	.03	00	.00	.00
31,	.07	.75	.....	.....	00	00	.....	.....	.04	00	....	.....
Totals,	3 46	17 15	1.70	4 40	2 905	11 5	2.79	.25	6 26	0.00	2 61	.00

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Meteorological Records for 1888. Precipitation in Inches (Rain and Snow).—CONTINUED.

DATES.	JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.	Total precipitation.	Snow.
1	00	00	0 15	.00	.00	.00	.52	.00	.00	.00	.03	00
2	00	00	.00	.00	.60	.00	.07	.00	.00	.00	00	.00
3	00	00	.00	.00	.00	.00	.00	.00	.15	.00	00	.00
4	00	00	.00	.00	.00	.00	.00	.00	.00	.00	.03	.5
5	00	00	.37	.00	00	.00	.00	.00	.00	.00	.06	.00
6	00	00	.00	.00	.00	.00	.25	.00	.11	.00	.00	.00
7	00	00	.00	.00	.00	.00	.03	.00	.14	.00	.00	.00
8	00	00	.00	.00	1 21	.00	00	.00	.31	.00	.00	.00
9	0 85	00	.00	.00	.00	.00	.00	.00	.15	.00	.23	.5
10	.15	00	.00	.00	.00	.00	.00	.00	.18	.00	.00	.00
11	00	00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.75	00	1 57	.00	.00	.00	.54	.00	.00	.00	.00	.00
13	00	00	00	.00	.00	.00	.27	.00	.00	.00	.00	.00
14	00	00	00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15	00	00	00	.00	.00	.00	.00	.00	.74	.00	.00	.00
16	00	00	00	.00	0 75	.00	.64	.00	.08	.00	.00	.00
17	00	00	.37	.00	0 44	.00	.00	.00	.00	.00	.50	.00
18	.04	00	00	.00	.00	.00	.00	.00	.00	.00	1 08	.25
19	.92	00	00	.00	00	.00	.71	.00	.62	.75	.08	.12
20	01	00	00	.01	0 72	.00	.....	.00	.00	.00	.02	.00
21	00	00	2 47	.00	00	.00	.....	.00	.00	.00	.00	.00
22	00	00	00	.00	00	.00	.....	.00	.00	.00	.00	.00
23	00	00	00	.00	.00	.00	.11	.00	.00	.00	.00	.00
24	00	00	00	.00	.00	.00	.13	.00	.00	.00	.00	.00
25	00	00	00	.00	.00	.00	.....	.00	.00	.00	.00	.00
26	00	00	00	.00	.00	.00	.02	.00	.21	.33	.00	.00
27	.07	00	00	.00	.00	.00	.15	.00	00	.00	.08	00
28	00	00	00	.00	.00	.00	.21	.00	00	.00	.00	.00
29	00	00	00	.00	.00	.00	.....	.00	.06	.00	.00	.00
30	00	00	00	.00	.00	.00	.....	.00	00	.00	.00	.00
31	00	00	1 23	.00	...	...	.....	.00	....	.....	.03	.00
Totals	2 78	.00	6 16	.00	3 12	00	3 76	.00	2.71	1 08	2.07	1.37

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Meteorologicol Records for 1888. Cloudiness.

Dates.	January.				February.				March.			
	7 A. M.	2 P. M.	9 P. M.	Mean	7 A M.	2 P M.	9 P. M.	Mean.	7 A M	2 P. M.	9 P. M.	Mean.
1,	10	10	10	10	3	10	10	8	10	10	10	10
2,	10	10	2	7	10	0	0	3 33	10	10	10	10
3,	10	10	10	10	2	2	3	2 33	9	3	7	6
4,	10	10	10	10	10	10	10	10	5	6	4	5
5,	10	2	0	4	10	10	10	10	10	10	0	7
6,	10	10	10	10	9	1	0	3 33	9	9	9	9
7,	10	10	10	10	10	10	10	10	10	10	2	7
8,	10	10	10	10	10	3	0	4 33	9	3	0	4
9,	10	10	10	10	4	4	0	3	0	0	0	0
10,	10	8	2	7	10	10	10	10	2	9	10	7
11,	2	8	0	3	10	10	10	10	10	10	5	8
12,	0	2	10	4	9	10	10	10	2	5	0	2
13,	10	9	0	6	10	0	0	3	10	10	5	8
14,	0	0	0	0	2	3	10	5	10	8	10	6
15,	10	10	6	9	1	0	0	.33	10	5	9	8
16,	0	10	0	6	0	0	0	0	10	10	10	10
17,	10	10	10	10	6	5	9	6 66	10	8	0	6
18,	10	10	0	7	10	10	0	6.66	0	0	0	0
19,	9	7	0	5	9	7	10	8 66	0	1	2	1
20,	10	8	3	7	10	10	7	9	8	8	1	6
21,	10	1	0	4	5	5	8	6	10	9	9	9
22,	9	3	0	4	1	0	0	.33	3	3	0	2
23,	10	10	10	10	5	0	0	1 66	2	4	0	2
24,	2	0	2	1	0	2	10	4	8	0	2	3
25,	10	10	10	10	10	10	10	10	8	10	10	9
26,	10	10	8	9	8	8	7	7 66	10	10	10	10
27,	10	4	4	6	2	7	1	3 33	10	10	9	10
28,	5	2	4	4	7	0	3	3 33	10	9	10	10
29,	3	10	10	8	10	10	10	10	10	5	0	5
30,	10	10	10	10	. . .	. . .	. . . .	. . . .	8	2	10	7
31,	10	10	10	10	. . . .	. . .	. . . .	. . . .	2	1	0	1
Means,	8 1	7 5	5.8	7.1	6 65	5.06	5 51	5.7	6 9	6 4	5	6 03

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Meteorological Records for 1888. Cloudiness—CONTINUED.

DATES.	APRIL.				MAY.				JUNE.			
	7 A. M	2 P. M.	9 P. M.	Mean	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A M.	2 P. M.	9 P. M	Mean.
1	1	4	0	2	10	10	10	10	4	1	3	3
2	10	2	1	4	10	7	0	6	10	10	0	7
3	0	0	0	0	10	9	1	7	1	4	9	5
4	0	0	0	0	0	3	10	4	0	4	0	1
5	6	10	10	9	5	1	0	2	0	1	2	1
6	10	0	0	3	0	6	0	2	4	2	8	5
7	0	1	0	.33	2	2	0	1	9	10	10	10
8	1	0	0	.13	10	10	10	10	5	1	0	2
9	0	0	2	.66	10	7	10	9	0	1	3	1
10	10	10	10	10	10	8	10	9	10	10	2	7
11	10	4	1	5	0	10	9	9	10	10	6	9
12	10	2	2	5	10	10	5	8	0	3	0	1
13	0	3	3	4	1	3	0	1	0	3	2	2
14	10	9	10	10	1	9	4	5	10	3	6	6
15	3	7	10	7	10	10	4	8	8	5	4	6
16	10	6	0	5	10	8	1	6	2	4	5	4
17	0	9	4	4	0	2	5	2	0	1	1	1
18	10	5	0	5	10	10	10	10	1	4	1	2
19	5	10	11	8	10	9	3	7	0	0	0	0
20	9	10	9	9	3	1	0	1	1	3	0	1
21	8	10	0	6	0	5	2	2	8	9	10	9
22	2	2	1	2	5	4	8	6	5	8	0	4
23	10	10	8	9	10	10	10	10	2	9	10	7
24	1	4	0	2	10	10	10	10	10	7	9	9
25	0	0	0	0	10	10	10	10	0	2	9	4
26	0	0	0	0	10	10	4	8	10	8	0	6
27	0	0	0	0	0	3	1	1	2	10	10	7
28	0	0	0	0	10	4	4	6	10	10	10	10
29	0	0	3	1	0	8	10	6	10	10	10	10
30	0	3	9	4	10	9	10	9	10	3	2	5
31	..		..	....	5	10	10	8	.	....	....	.....
Means	4 2	4 3	3 26	31 77	6.5	7 0	5 5	6 3	4.7	5.4	3 8	4 6

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Meteorological Records for 1888. Cloudiness—Continued.

Dates.	July.				August.				September.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.
1	0	6	0	2	10	3	0	5	10	10	10	10
2	0	2	0	1	0	5	9	4 6	1	2	0	1
3	1	2	0	1	1	9	0	3.3	10	9	10	10
4	0	1	0	0	5	6	9	6.6	10	9	0	6
5	10	10	8	9	10	10	10	10	0	2	0	1
6	0	1	9	3	10	3	0	4 3	6	3	0	3
7	7	4	3	5	5	3	0	2 6	9	10	10	10
8	0	. . . .	1	3	3	4	1	2 6	10	10	10	10
9	10	10	10	10	9	5	0	4 6	10	6	9	8
10	10	4	0	5	0	1	0	.3	9	9	8	9
11	0	5	3	3	3	7	4	4 6	10	9	5	8
12	7	9	4	7	6	7	10	7 6	5	8	10	8
13	7	5	7	4	9	6	0	5	4	4	0	3
14	9	7	3	3	1	1	0	.6	0	0	0	0
15	8	1	0	3	3	10	9	7 3	10	10	9	10
16	0	4	0	1	4	7	2	4.3	10	10	10	10
17	0	7	5	4	10	10	2	7 3	10	10	10	10
18	10	10	10	10	5	10	7	7 3	1	4	5	3
19	10	8	8	9	1	5	0	2	7	6	7	7
20	10	7	0	6	9	7	3	6.3	10	9	8	9
21	0	1	0	0	10	10	10	10	2	3	0	2
22	1	1	0	1	9	5	0	4 6	1	4	9	5
23	4	5	6	5	0	1	0	3	3	5	6	5
24	9	8	0	6	0	0	0	0	10	7	1	6
25	0	5	1	2	1	0	0	3	10	10	10	10
26	1	8	9	6	1	3	0	1 3	6	9	2	6
27	10	5	8	8	10	9	0	6.3	9	6	2	6
28	1	. . . .	0	0	0	4	0	1.3	4	7	3	4
29	1	5	0	2	0	5	1	2	5	8	3	5
30	10	4	0	5	0	0	0	0	9	8	10	9
31	7	8	0	5	10	10	10	10	. .	.	.	. .
Means	4	5	3	4.1	4 7	5 4	2 5	4 2	6.7	6 8	5.5	6 4

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Meteorological Records for 1888. Cloudiness—CONTINUED.

DATES.	OCTOBER.				NOVEMBER.				DECEMBER.			
	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9 P. M.	Mean.	7 A. M.	2 P. M.	9P. M.	Mean.
1,	10	6	10	8 6	0	0	0	0	9	8	7	8
2,	9	9	4	7 3	4	6	10	7	10	7	0	6
3,	1	5	3	3	10	3	0	4	10	10	10	10
4,	5	7	2	4 6	0	4	7	4	7	8	1	8
5,	9	5	10	8	7	8	2	6	2	8	10	7
6,	10	10	6	8 6	9	5	10	8	10	7	9	9
7,	10	9	10	9 6	7	8	10	8	3	4	0	2
8,	10	5	3	6	9	10	10	10	8	10	10	9
9,	10	6	2	6	10	10	10	10	10	9	8	9
10,	0	0	3	1	9	10	6	8	10	10	10	10
11,	10	10	10	10	7	8	0	5	10	10	10	10
12,	10	10	8	9 3	0	0	0	0	10	9	9	9
13,	10	10	10	10	0	0	0	0	8	9	8	8
14,	9	10	7	8 6	0	7	8	5	7	8	0	5
15,	10	10	10	10	10	10	6	9	8	10	10	8
16,	9	9	9	9	10	9	8	9	8	10	10	8
17,	9	7	6	7.3	1	8	0	3	10	10	10	10
18,	9	8	2	6 3	9	9	10	9	10	10	8	9
19,	10	10	5	8 3	10	10	4	8	10	7	7	8
20,	1	10	8	6 3	1	4	2	2	10	7	8	8
21,	9	8	6	8 3	0	0	0	0	8	9	6	8
22,	10	10	10	10	0	0	0	0	0	2	0	1
23,	10	10	10	10	0	0	7	2	0	0	0	0
24,	10	8	0	6	0	0	4	1	0	0	2	1
25,	2	1	0	1	5	0	9	5	3	8	6	6
26,	10	10	10	10	10	10	10	10	9	8	9	9
27,	10	10	10	10	10	10	10	10	9	10	8	9
28,	10	6	5	7	10	10	10	10	10	9	9	9
29,	7	9	0	5 3	10	10	10	10	0	0	0	0
30,	1	2	0	1	1)	1)	10	10	0	0	7	2
31,	6	3	4	4 3	.....	...	...	.	10	10	10	10
Means,	7.9	7.8	6 1	7 2	5 6	5 9	5 8	5 8	6 7	7 3	6 8	7 0

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Meteorological Records for 1888. Wind.

Day.	January.										February.									
	Direction.			Velocity in miles per hour.			Anemometer record.				Direction.			Velocity in miles per hour.			Anemometer record.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.	7 A.M.	2 P.M.	9 P.M	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.
1,	S	W	W	0	10.8	0	279.3	286.8	290.0	46.9	NE	NE	N	0	0	10.8	319.2	326.0	314.4	25.2
2,	W	W	W	0	18.0	0	334.0	391.8	408.0	118.0	NE	E	E	0	0	0	368 9	370.3	370.3	25.9
3,	W	W	W	0	3.6	1.2	408.0	415.0	462.4	54.4	E	E	NE	0	0	0	370.3	370.3	370.3	.0
4,	W	W	SW	0	0	0	463.7	463.7	463.7	1.3	S	S	S	0	0	0	370.3	391.3	391.3	21.0
5,	NE	E	E	0	0	0	466.2	466.2	466.2	2.5	W	W	W	0	0	0	408.0	424.0	429.0	37.7
6,	SW	SW	SW	0	0	0	466.3	466.3	467.3	1.1	W	W	W	0	0	0	448.7	448.7	4 0.8	21.8
7,	S	S	SW	0	0	0	467.3	467.3	467.4	.1	S	S	S	0	0	0	453.2	453.3	453.3	2.5
8,	W	W	NW	0	14.4	0	474.1	490.0	9.3	31.9	SW	W	W	0	18.0	0	454.6	470.3	2.9	49.6
9,	W	NW	NW	0	0	0	28.4	28.4	28.4	19.1	W	W	W	4.8	0	0	12 0	55.9	89.1	76.2
10,	W	W	W	0	16.8	12.0	39.7	127.4	208.8	178.4	W	SW	SW	0	0	0	90.4	90.4	90.4	1.3
11,	W	W	W	3.6	16.8	0	325.7	43.7	454.7	247.9	NW	N	NW	0	0	0	90.5	90.5	90.5	.1
12,	W	W	S	0	0	9.6	454.7	454.7	491.2	36.5	N	N	N	0	0	0	90.5	90.5	90.5	.0
13,	S	SW	W	7.2	0	0	52.4	60.0	67.5	76.3	NW	W	SW	0	0	0	90.5	90.5	91.2	.7
14,	W	W	NW	0	0	0	67.9	67 9	68.0	.5	SW	SW	S	0	2.0	3.0	91.5	95.4	110.9	19.7
15,	NW	N	W	0	10.8	12.0	74.7	89.0	17 .9	104.9	NW	NW	NW	12.0	18.0	0	226.7	388.0	404.3	293.4
16,	N	N	N	0	0	0	261.1	261.3	261.3	88.4	NW	W	S	0	4.8	0	405.3	408.6	426.3	22.0
17,	SE	S	S	2.0	0	0	268.7	268.7	285.3	24.0	W	W	W	6.0	0	0	25.7	47.7	58.3	29.0
18,	W	W	W	3.6	15.6	21.6	328.0	375.5	.	.	W	W	W	0	3.6	0	59.3	92.3	9 .8	42.5
19,	W	SW	W	4.8	14.4	0	158.1	222.3	265.8	265.8	W	S	S	0	3.0	3.6	97.8	105.2	133.9	36.1
20,	W	W	W	28.8	13.2	0	320.0	423.9	458.5	192.7	S	S	W	0	0	0	157.1	173.9	188.9	55.0
21,	W	NW	N	4.8	16.8	0	477.4	49.0	98.5	40.0	W	W	W	2.6	0	0	276.4	303.4	306.9	118.0
22,	NW	W	W	0	0	0	98.6	98.6	98.6	.1	W	W	W	0	0	0	308.0	310.2	311.4	4.5
23,	W	W	NW	0	0	0	98.6	98.6	98.6	0	W	S	S	0	0	0	311.4	313.4	314.1	2.7
24,	W	NW	N	7.5	6.0	0	258.1	311.9	312.9	214.3	W	E	E	0	7.6	9.6	315.3	320.5	367.9	53.8
25,	NW	S	SW	0	12.8	0	315.5	341.0	355.4	42.5	E	E	W	0	0	0	411.7	411.7	412.7	44.8
26,	W	W	W	15.6	34.8	27.6	465.4	120.0	298.6	143.2	W	W	W	0	0	0	448.6	484.0	.7	188.0
27,	W	NW	NW	9.6	28.2	21.0	451.7	62.2	287.8	239.2	W	W	W	0	12.0	15.6	3.2	34.9	180.5	129.8
28,	W	NW	NW	9.6	27.6	4.8	393.5	27.8	170.5	282.7	W	W	W	14.0	3.6	0	245.7	317.7	326.4	95.9
29,	W	NW	NW	3.6	0	0	302.9	316.0	318.6	148.1	W	W	W	0	0	0	326.4	326.5	326.5	.1
30,	NW	SW	SW	0	0	0	319.1	319.1	319.1	.5	. . .	. . .	. . .	. . .	. . .	. . .	. .	. . .	. . .	. . .
31,	N	N	NE	0	0	0	319.2	319.2	319.2	.1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Prevailing direction,	. . .	W	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	W, SW	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Total movement,	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	2,651.4	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1,507.3

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Meteorological Records for 1888. Wind—CONTINUED.

DAY.	MARCH.										APRIL.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.				DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.
1,	W	W	NW	0	0	0	326.5	326.5	326.6	.1	W	S	W	0	0	0	28.4	30.2	30.2	1.8
2,	SW	SW	S	0	0	0	326.6	327.5	327.6	1.0	W	W	W	6	4.8	7.2	....	168.7	272.2	242.0
3,	W	W	NW	13.2	32.0	12.0	391.2	26.6	151.3	126.7	W	N	NW	0	6.0	0	.	310.0	316.1	43.9
4,	NW	NW	NW	12.0	12.0	10.8	361.6	327.4	370.7	226.4	SE	W	NW	0	0	0	317.2	326.2	345.6	29.5
5,	E	E	SE	0	0	0	379.5	380.6	380.6	10.1	S	S	SW	12.0	0	0	366.7	407.6	414.3	68.7
6,	SW	W	W	0	18.5	6.0	485.6	485.1	29.6	238.8	W	W	SW	8.4	19.2	12.0	440.7	499.7	125.5	11.2
7,	W	W	W	6.0	8.4	0	40.2	71.7	117.1	87.5	SW	W	SW	13.5	16.8	2.4	234.8	351.2	474 3	348.8
8,	NW	NW	N	0	9.6	0	129.3	214.7	288.4	171.3	NE	N	NW	4.0	2.4	0	1.4	9.8	28.5	54.2
9,	N	N	N	0	0	0	324.0	324.7	344.9	36.5	W	SW	S	0	0	2.4	28.6	31.4	48.7	20.2
10,	S	S	S	0	3.0	7.2	324.9	350.9	379.0	54.1	S	SE	SE	4.8	0	3.6	102.3	131.7	159 3	110.6
11,	S	SE	W	0	0	10.8	406.8	408.1	490 0	11.0	W	W	W	13.2	25.9	0	238.7	350.5	396.2	186.9
12,	NW	NW	NW	21.6	30.0	13.2	125.7	282.4	483.0	98.0	W	W	N	0	12.0	13.2	400.7	450.7	76.8	80.6
13,	W	NW	NW	10.8	14.4	10.8	155.2	280.5	400.7	17.7	W	W	SW	2.4	0	4 8	130.1	. . .	149.8	72.5
14,	W	W	W	6.0	10.0	0	410.2	27.3	142.0	341.3	SW	W	W	2.4	15.6	20.4	180.9	282.3	417.1	267.8
15,	W	W	SW	9.6	4.5	0	178.3	209 6	219.6	77.6	W	W	W	7.5	0	0	1.6	8.2	9.6	9'.5
16,	SW	SW	SW	0	7.5	14.0	225.8	235.0	252.9	33.3	E	NE	N	0	9.6	0	10.3	60.6	127.5	117.9
17,	N	N	N	0	0	0	287.7	290 8	308.5	55.6	N	NE	SE	0	0	0	131.0	131.2	136.7	9.2
18,	E	E	E	0	0	0	308.5	308.5	308.5	.0	SW	W	W	0	8.0	0	142.5	158.0	190.7	51.0
19,	SW	S	S	0	0	0	308.5	317.5	337.7	29.2	W	SW	W	0	6.0	0	190.7	198.7	206.7	16.0
20,	SE	S	S	2.4	12.6	0	356.3	422.7	440.8	103.1	W	NW	NW	0	16.8	9.6	228.9	309.5	380.3	173.6
21,	SW	W	W	0	12.0	19.2	446.2	8.4	93.1	312.3	N	N	W	0	20.4	0	425.0	487.5	51.0	170.7
22,	W	W	W	10.8	18.0	12.0	177.3	242.2	360.7	267.6	W	W	W	0	9.6	0	56.4	100.0	114.9	63.9
23,	W	W	W	22.8	16.8	0	463.0	76.0	162.0	101.3	W	N	N	0	10.5	12.0	115.3	145.3	203.8	88.9
24,	W	NW	N	0	13.2	0	163.7	180.0	208.7	41.7	W	N	W	7.5	15.0	0	220.2	322.5	409.3	191.5
25,	N	NE	NE	0	0	0	203.8	203.9	203.9	0.2	N	SW	S	0	0	0	408.3	408.0	408.7	.4
26,	E	E	SE	0	0	0	201.0	225.1	225.1	21.2	S	S	S	0	.3	0	408.8	413.5	417.3	8.6
27,	SE	W	SW	0	0	0	225.1	225.1	225.1	.0	E	E	E	0	0	0	417.3	417.4	417.4	.1
28,	S	SW	S	0	0	0	225.1	225.4	225.5	.4	SE	E	NE	0	0	0	417.4	417.4	417.4	.0
29,	NW	NW	NW	3.6	12.0	0	288.5	297.1	322.7	107.2	W	NW	NW	0	7.5	0	417.5	427.0	443.9	26.5
30,	W	SW	SW	0	16.8	0	329.3	337.5	359.2	29.5	SW	SW	W	0	0	3	443.9	451.9	476.2	32.3
31,	SW	W	NW	10.8	18.0	0	402.4	471.7	28.4	179.2	....	...	....	....	....	...	....	..	...	. ..
Prevailing direction,	....	W, NW	....	...	....	...	...	...	....		....	W	....	...	....	....	...	...	....	
Total movement,	....	....	...	...	...	...	...	...	...	2,801.9	...	....	...	...	....	....	....	...	....	2,537.8

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Meteorological Records for 1888. Wind—Continued.

Day.	May.										June.									
	Direction.			Velocity in miles per hour.			Anemometer record.				Direction.			Velocity in miles per hour.			Anemometer record.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P. M.	9 P.M.	7 A.M.	2 P. M.	9 P. M.	Daily move ment.	7 A. M.	2 P.M	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P M	9 P.M.	Daily move-ment.
1,	NW	NW	NW	14.4	12.0	6.0	490.0	70.8	132.4	66.2	W	NW	NW	0	0	0	426.2	481.5	1.6	78.4
2,	N	N	NE	14	2.4	0	202.1	250.0	256.1	123.7	NW	W	W	0	0	0	1.6	31.1	56.3	54.7
3,	NE	S	SE	0	3	0	256.1	279.0	319.0	52.9	W	N	NE	0	6.0	3.0	56.3	70.5	79.1	22.8
4,	NE	SE	SE	6.0	4.8	0	338.2	365.0	409.5	90.5	NW	W	W	0	0	0	79.4	79.4	88.5	9.4
5,	W	W	N	2.4	6.5	0	419.1	471.2	22.0	12.5	W	S	SW	0	0	0	88.6	108.9	122.9	34.4
6,	W	W	W	0	15.6	0	22.7	70 1	123.0	101.0	W	NW	W	0	6.0	2.4	123.1	137.2	172.6	49.7
7,	NE	SE	E	0	0	0	125.0	130.8	131.8	8.8	W	NW	NW	2.4	3.6	0	190.6	214.7	229.5	56.9
8,	SE	SE	SE	3.0	3.6	0	133.2	144.7	160.5	28.7	NW	S	SE	0	0	0	233.9	234.8	245.3	5.8
9,	SE	S	S	0	0	0	160.5	163.3	178.2	17.7	S	S	S	0	6.0	2.0	285.3	283.4	288.5	53.2
10,	SE	S	S	0	0	0	178.2	179.6	189.1	10.9	SW	SW	S	1	3	0	289.8	306.4	319.7	31.2
11,	SE	E	E	0	3.6	0	191.2	220.5	226.8	37.7	SW	NW	W	0	10	0	329.1	390.0	438.6	118.9
12,	E	S	W	0	2.0	0	226.8	231.1	237.4	10.6	SW	SW	SW	0	0	0	438.7	438.7	438.7	0.1
13,	W	W	W	0	0.6	0	238.2	242.5	254.1	20.7	SW	SE	SE	0	8	0	438.7	478.7	21.6	85.9
14,	W	E	E	0	0	4.8	258.1	261.9	285.6	25.5	SW	W	W	0	8.0	0	26.0	50.3	70.8	46.2
15,	W	SW	SW	4.8	3.0	0	306.9	345.0	253.6	70.0	SW	W	W	0	11.0	0	70.8	111.0	129.0	58.2
16,	W	W	W	0	7.2	0	353.6	368.5	423.0	69.4	W	NW	W	0	3.6	0	129.0	161.0	183.1	56.1
17,	W	NW	NW	0	0	0	423.5	428.5	429.0	6.0	W	W	W	0	0	0	185.1	185.3	185.3	0.2
18,	E	SE	SE	0	0	0	429.5	429.5	430.2	1.2	W	W	NE	0	3.6	. . .	185.3	188.6	191.5	6.2
19,	W	NW	W	0	12.0	0	448.0	455.2	18.8	88.6	NE	W	W	0	0	0	195.8	195 8	195.8	4.3
20,	W	N	NE	0	0	0	38.3	50.5	76.9	58.1	W	NW	W	0	2.4	0	195.9	197.2	204.4	8.6
21,	NE	NE	SW	0	0	0	77.0	77.4	80.2	3.3	W	W	W	0	0	0	204.4	204.4	221.4	17.6
22,	SW	SE	SE	0	6.0	0	80.7	99.9	128.0	47.8	W	W	W	0	9.6	0	222.2	223.2	225.9	4.5
23,	E	E	E	0	8.4	1.0	129.0	140.9	159.4	31.4	W	W	W	0	0	0	225.9	230.8	239.2	13.3
24,	E	E	E	0	0	0	117.1	162.5	165.5	6.1	W	SE	W	0	0	0	239.2	239.6	240.8	1.6
25,	E	E	E	0	6.0	0	165.8	175.5	236.1	70.6	W	NE	W	0	4.8	0	252.7	274.8	277.1	36 3
26,	SE	S	SW	3.6	0	0	242.6	248.0	249.0	12.9	W	W	W	0	24	0	277.1	295.0	314 9	37.8
27,	SW	S	S	0	6.0	0	249.0	256.7	292.0	43.0	E	S	S	0	3.6	0	314.9	315.8	323.9	8.9
28,	S	S	S	0	8.0	6.0	305.2	316.1	375.7	83.7	E	E	E	6.0	0	0	378.5	405.8	441.3	117.5
29,	E	W	W	0	0	0	382.9	404.0	410.4	34.7	E	E	E	0	0	0	464.2	468.5	468.7	22 4
30,	S	SW	SW	0	0	0	414.2	418.4	415.5	5.1	W	NW	NW	0	4.8	15.6	463.7	483.6	38.9	75.2
31,	SE	SE	SE	0	0	0	415.5	416.0	423.2	7.7	. . . .	. . . .	. . .	. .	. . . .	. . .	. .	. .	. . . .	. . .
Prevailing direction,	. . . .	S & E	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	1,247.0	. . . .	W	. . .	. . . .	. . . .	. . .	. . .	. . . .	. . . .	. . .
Total movement,	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	. . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . .	. . . .	. . . .	. . .	1,246.2

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Meteorological Records for 1888. Wind—CONTINUED.

DAY.	JULY.										AUGUST.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.				DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M	2 P.M.	9 P.M.	Daily movement.	7 A. .	2 P.M.	.M.	7 A.M.	P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.
1,	NE	E	E	0	8.4	4 8					W	W	W	0	2 4	0	42 9	64.5	78 7	
2,	E	E	E	0	0	0					W	W	W	0	0	0	78.7		88 3	9 6
3,	E	S	E	0	0	0					W	W	W	0	2.4	0	88 4	88 6	88 9	.6
4,	S	SW	W	0	2 4	0					W	W	W	0	0	0	89.3	103.9	120 5	31 6
5,	W	W	W	0	0	10.8					W	E	E	0	2 4	0	120 5	122	126.8	6 3
6,	W	W	SW	0	0	0					E	W	S	0	0	0	126 8	126.9	133 9	7 1
7,	W	W	NW	0	3 6	5.0					W	W	W	0	0	0	133 9	164.5	174 0	40.1
8,	W		W	0		0					W	W	W	0	1.2	0	175 0	183 6	201.4	27.4
9,	NW	E	E	0	3 6	0					W	W	W	0	3 6	0	201 5	227 9	256 5	55.1
10,	E	W	W	0	1.2	0					W	W	W	0	0	0	256 7	259 7	264 8	8 3
11,	W	NW	NW	0	28 8	14.4					E	E	W	0	0	0	264 8	264 9	265 0	2
12,	NW	W	W	12.2	0	0					W	S	S	0	0	0	265 0	271 1	279 3	14 3
13,	W	NE	E	0	10 8	0					N	N	N	4 8	7 2	0	294 6	327 3	352 9	73 6
14,	E	E	E	0	0	0					W	SW	W	0	0	0	356 0	348.2	348 2	95.3
15,	W	N	W	0	0	0					W	W	W	0	0	0				
16,	E	E	E	0	0	0					W	W	W	0	0	0		361 0	366.5	18.3
17,	E	S	S	0	8.4	0					W	SW	S W	0	0	0	9 4	11 2	23 2	56 7
18,	S	S	S	4.8	3.6	2.4					S	W	W	0	0	0	23 4	24.5	27.1	3.9
19,	S	S	S	0	3.6	0					E	W	W	0	0	0	27 1	31.4	31 7	3 6
20,	N	N	N	0	0	0					W	W	W	0	0	0	35 6	36 4	36 5	4 8
21,	E	E	E	0	0	0					N	E	E	0	0	0	36 5	42 7	50 5	14 0
22,	S	W	N	0	0	0					N	N	N	8 4	7 2	0	79 8	133 6	162 2	111.7
23,	W	SW	W	0	0	0					NW	NW	W	0	6 0	0	167 2	187.1	219.1	56 9
24,	W	W	W	0	7.2	0					NW	NW	W	0	3 6	0	219.4	245 1	245.8	26.7
25,	W	W	W	0	0	0					W	W		0	0	0	250 0	262 5	272 5	26 7
26,	W	W	W	0	0	0					W	W	W	0		0	272 6	281 2	287 7	15 2
27,	W	E	E	0	0	0					W	NW	NW	0	3 6	6 0	293 4	343 9	343 9	56 2
28,	SE	S	S	0		0					W	W	W	0	0	0	343.9	343 9	343.9	0 0
29,	E	E	E	0	6 0	0					W	W	W	0	0	0	344.2	344 2	344 2	.3
30,	E	S	S	0	0	6 0					W	W	W	0	0	0	344 2	344 5	344 7	.5
31,	S	W	W	0	0	0					NW	NW	E	0	0	2.4	344 7	344 7	350 5	5 8
Prevailing direction,		W, E								972.4										
Total movement,																				877 6

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Meteorological Records for 1888. Wind.—CONTINUED.

DAY.	SEPTEMBER.										OCTOBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.				DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M	2 P.M.	9 P.M.	Daily movement.
1,	E	E	E	0	2.4	0	350 9	355.5	357 1	6 6	W	W	W	0	0	0	493.9	23 9	33 9	44.4
2,	E	E	E	0	0	0	357 1	360 3	360.3	3 2	NW	NW	W	7 2	8 4	0	51 8	92 3	145 1	111.2
3,	E	E	E	0	0	0	360.3	373 9	373 9	13 6	W	NW	W	0	8 4	0	160.0	202.4	218.9	73 8
4,	E	W	W	0	1.2	0	373 9	378	385.8	11.9	W	W	W	0	0	0	223 9	231.6	248 7	29 8
5,	E	E	E	0	0	0	394 2	399.7	399.9	14 1	W	W	W	0	2 4	0	248 7	252.4	252.6	3.9
6,	E	E	E	0	6 0	0	399 9	415.1	425 4	25 5	E	W	SW	0	0	7 2	253.2	253.9	288.1	15 5
7,	E	E	E	0	0	0	425 4	464.8	464 8	39 4	NE	NW	W	0	4 8	0	304.4	342 8		
8,	SW	W	W	0	0	0	464 9	464.9	464 9	.1	NW	NW	NE	3 6	2.4	7 2	360.4	398 6	470 9	212 8
9,	W	W	W	0	0	0	464 9	467 3	475.1	10 2	W	NW	W	9 6	7 2	0	39.7	127 0	168 9	98 0
10,	W	W	W	0	0	0	478.1	478.2	478 2	3.1	E	W	W	0	6	0	175 0	203 2	203 6	34 7
11,	E	E	E	0	0	0	478 2	480 3	480 3	2 1	E	E	E	0	0	0	208 7	207.9	211 2	7.6
12,	W	W	W	0	0	0	481 5	493 4	5 5	25 2	W	W	W	0	0	0	220.1	228 7	229 2	18 0
13,	W	NW	W	0	0	0	5.8	56 8	68.9	63 4	W	W	W	0	0	0			229 9	.7
14,	SE	W	W	0	12	0	71.6	71.8	78 4	9 5	W	NW	W	0	9.6	0	230.0	233 7	298 0	68.1
15,	W	W	SW	0	3.6	4.8	78 4	102.9	125 1	46 7	W	W	W	0	0	0	298 0	298 1	298.7	.7
16,	SE	SW	W	7 2	6	0	153 7	250 2	250 5	125 4	W	W	W	2.4	3 6	0	300 0	313 2	339 9	41 2
17,	W	N	W	0	0	0	250 5	250 7	250 7	.2	W	W	W	1.2	0	1 2	343 4	378 6	385 2	45 3
18,	W	E	E	0	0	0	250 7	250.7	250 8	1	W	W	W	0	4 8	0	387 3	409 5	413 0	27.8
19,	W	N	W	0	0	0	250 9		258 1	7 3	W	W	W	0	0	9 6	419 0	469.0	422.2	9.2
20,	W	N	W	0	0	0	288 1	259 7	259 7	1 6	NW	NE	NE	0	4.8	6.0	439 6	439 7	27 5	5 3
21,	W	N	W	0	24	3 6	259.7	270 8	280 1	20.4	W	NE	NE	0	7 2	0	71 8	138 9	138 1	110 6
22,	W	W	W	0	0	0	280 3	280 3	281 0	.9	E	W	SE	0	0	0	145.2	145 2	145 3	7 2
23,	W	S	W	0	0	0	289 8	289 8	289 8	8 8	NE	E	E	0	0	0	145.3	145 3	145 3	0 0
24,	W	E	E	0	0	0	289 9	289 9	289 9	.1	E	NE	E	6.0	7 2	0	152.4	241.4	269 3	124 0
25,	E	E	E	0	0	0	293 9	293 9	293 9	4 0	W	W	W	0	4 8	0	269.3	272 2	278 1	8 8
26,	W	NW	W	0	3 6	0	293 9	297.0	300.1	6 2	SE	W	SW	10	4 8	3.6	231 2	300.7	342 8	64 7
27,	NW	NW	NW	1.0	10 8	0	328 9	369.9	393.1	93 0	W	S	S	0	0	0	352 1	362 1	362 1	19 3
28,	NW	NW	NW	0	0	0	385 8	408 7	437 1	34.0	NW	N	NW	0	6.0	3 6	362 2	380 6	400 1	38.0
29,	NW	NW	NW	0	8 4	0	432 8	445 9	464.9	37 8	N	NW	NW	8.4	3 6	0	38 8	86 6	89 6	89 5
30,	NW	NW	NW	0	0	0	465 4	481.9	489.5	24 6	W	N	N	0	0	0	132 9	175 9	183.2	94 6
31,	....	....	..	....	....	....	..	..	....	....	....	....	W	0	0	0	183.5	204 1	211 2	28.0
Prevailing direction,	....	W, NW	....	....	....	....	....	....	....	....	....	W	....	....	....	....	....	....	....	
Total movement,	....	....	....	....	....	....	....	....	....	689.0	....	....	....	....	....	..	..	....	....	1219.9

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Meteorological Records for 1888. Wind—CONTINUED.

DAY.	NOVEMBER.										DECEMBER.									
	DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.				DIRECTION.			VELOCITY IN MILES PER HOUR.			ANEMOMETER RECORD.			
	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	Daily movement.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M.	9 P.M.	7 A.M.	2 P.M	9 P.M.	Daily movement.
1,	W	W	W	0	6 0	0	211.2	234 7	234 7	23.5	NW	NW	NW	6 0	2 4	4 8	434 4	481 6	42 3	142 3
2,	W	W	W	0	2 4	0	238.1	273.8	303 1	68 4	W	W	W	3 6	0	2.4	57 9	67 8	78 6	86.3
3,	W	W	W	3.6	6 0	0	308 7	308.7	387.1	84.0	W	NW	NW	2 6	4 8	0	110.5	137 4	145 2	66 6
4,	W	W	W	0	0	8 4	397 2	401 3	415 9	28.8	W	N	W	7 2	2 4	0	171.8	226 8	254 3	109.1
5,	W	W	W	0	0	0	450.2	450.2	486.3	70 4	W	S	S	0	2 4	4 8	279 0	239 1	289 1	34 8
6,	W	W	W	0	7.2	0	487.6	6 8	25 5	39 2	NE	NE	NE	6	7 2	7.2	396.9	489 4	50 6	361 5
7,	E	E	E	1 2	0	0	55.2	62.1	63 9	38 4	W	W	W	0	3 6	0	61 3	79.1	88 3	37 7
8,	E	E	E	7.2	0	0	73 6	91.2	137 6	73 7	W	W	W	0	0	0	90 1	90 1	90 2	1 9
9,	E	E	E	0	0	0	133 9	134 0	135 1	197.5	W	W	W	0	0	0	90 9	91 4	92 4	2 2
10,	SW	SW	W	1 2	3 6	8.4	154 6	200.8	247 6	112 5	E	E	E	0	0	0	92 8	112.3	122.1	29.7
11,	NW	NW	W	7.2	6 0	0	370 9	479 1	10 9	163 3	W	NW	NW	0	4 2	1 2	122 1	135 8	224 6	02 5
12,	W	W	W	0	2 4	0	19 3	43 7	54	43.1	NE	NE	NW	7.2	3.6	1 2	360 8	448 4	493 7	289 1
13,	W	W	W	0	1.0	0	54	63 9	67 2	13 2	W	W	W	1 0	2.4	7 2	4 3	177 3	177 3	83 6
14,	W	W	W	0	0	0	67 3	74 6	74 6	7 4	W	NW	NW	7 2	12 0	0	298 1	427 3	3	323.0
15,	E	E	E	0	0	0	74 6	74 6	76.4	1.8	W	W	W	0	0	0	3 9	3 9	3 9	3 6
16,	NW	NW	NW	4.5	0	1 2	87 9	108.7	136	59 6	W	W	W	0	0	0	3 9	3 9	34 5	30 6
17,	W	NW	NW	0	0	0	145 9	188 8	214 4	78 4	W	W	W	0	0	20	38 2	43 2	67 8	33 3
18,	NW	NW	NW	1.2	0	0	227 0	260 4	283 6	69 2	W	W	W	3.6	7 2	3.6	274 1	357 5	440 2	372.4
19,	SW	SW	E	0	0	4.8	288 7	288 7	288.9	5 3	W	W	W	0	24	0	484.2	18 8	50 4	110 2
20,	NW	NW	E	4.8	3 6	0	376 7	403 6	414 9	126.0	W	W	W	0	0	0	51 3	75.6	82 3	31 9
21,	E	E	E	0	0	0	44 9	415 0	418	1	W	NW	NW	0	6.8	8 4	92 6	150 9	252 2	199 9
22,	E	E	E	0	0	0	415 0	415.0	417	2 0	W	W	W	0	0	0	349.2	349.2	349 5	67 3
23,	E	W	W	0	4 8	0	417.0	422.5	450	33 0	W	W	W	0	0	0	351	353.4	353 4	3.9
24,	W	W	W	0	0	0	452 5	459 2	459 2	9 2	W	W	W	0	0	0	354 1	354 1	354 1	.7
25,	E	E	E	0	0	8.4	459 2	477 0	59.1	59 9	W	W	W	1.2	0	0	356 4	370 4	372 2	18 1
26,	E	E	E	6 0	4.8	0	185.4	291 5	300.5	241 4	W	W	SW	0	0	3.6	372 2	382 1	436 7	64 5
27,	E	W	W	0	0	0	301 5	310 5	320 1	19 6	W	NW	NW	0	4.8	8 4	478 2	5.9	8 2	149.5
28,	N	N	N	0	4.8	0	320 6	334 1	334 8	14 7	NW	NW	NW	7.2	2 4	4 8	165 2	221 9	233 2	147 0
29,	W	W	W	0	0	0	334 8	334 8	334 8	0.0	W	W	W	0	0	0	238 8	252 2	255 9	22 7
30,	W	NW	NW	7.2	4 8	0	369.2	393.9	400 0	65 2	W	W	W	0	2 4	0	258 9	262 1	269 7	13.8
31,	..	....	....	.	...	.	. .	. .	.		W	W	W	. 0	0	0	289 7	272 2	291.6	21 9
Prevailing direction,	....	W	....	....	.....	....	....	....	....		....	W	....	.....	.....	.....	.....	.....	.....	
Total movement,	....	....	....	....	.....	....	....	....	....	1,688 8	....	...	...	...	.....	.....	....	....	.....	2 891 6

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Soil Temperature Records for 1888. April.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.
1,	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....
2,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
3,	....	....	....	...	....	....	....	....	....	....	....	....	....	....	....
4,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
5,	48.00	50.00	50.00	49.50	2.00	40.00	46.50	48.50	45.87	8.50	38.00	44.50	47.00	44.12	9.00
6,	50.00	64.00	45.00	51.00	19.00	48.50	59.00	44.00	48.87	15.00	48.50	57.00	45.25	49.00	11.75
7,	40.00	58.00	31.00	40.00	27.00	38.50	53.50	37.50	41.75	16.00	37.50	51.00	39.50	41.87	13.50
8,	32.00	64.00	34.00	41.00	32.00	32.75	54.50	39.50	41.56	21.75	34.25	52.50	40.75	42.01	18.25
9,	34.00	61.00	44.00	46.50	30.00	38.50	58.75	44.00	45.06	25.25	34.50	58.50	45.00	44.50	19.00
10,	41.00	46.00	48.00	45.75	7.00	41.00	48.25	45.00	43.56	4.00	41.00	42.25	44.50	43.06	3.50
11,	44.00	54.00	40.00	44.50	14.00	41.50	45.50	42.00	42.75	4.00	41.50	44.00	43.00	42.87	2.50
12,	40.00	48.00	32.00	38.00	16.00	40.50	43.50	36.00	39.00	7.50	40.50	43.25	38.25	40.06	5.00
13,	32.00	48.00	41.00	40.50	16.00	32.25	39.00	39.00	37.31	6.75	34.50	37.50	39.50	37.75	5.00
14,	40.00	46.00	36.00	39.50	10.00	39.00	41.25	38.00	39.06	3.25	38.50	41.25	38.00	39.98	3.25
15,	38.00	34.00	42.00	39.00	8.00	35.00	45.50	42.50	41.37	10.50	37.50	43.00	43.00	41.50	5.50
16,	34.00	53.00	36.00	39.75	19.00	36.00	44.00	38.50	39.25	8.00	37.50	42.75	49.50	39.81	5.25
17,	35.00	50.00	33.00	40.25	15.00	33.75	48.25	40.50	40.75	14.50	35.50	42.00	41.75	40.25	6.50
18,	44.00	52.00	38.00	48.00	14.00	39.75	45.75	41.50	42.12	6.00	39.75	44.00	43.00	42.50	4.25
19,	40.00	53.00	40.00	43.25	13.00	36.50	47.50	43.00	42.50	5.00	37.00	45.50	43.25	42.25	8.50
20,	36.00	41.00	34.00	36.25	7.00	36.75	40.50	36.00	37.31	4.50	38.50	40.50	37.50	38.50	3.00
21,	36.00	41.00	33.00	35.25	8.00	34.00	38.50	35.00	35.62	4.50	35.00	38.50	35.50	36.12	3.50
22,	33.00	51.00	40.00	41.00	18.00	33.50	41.00	41.25	39.25	7.75	34.50	39 50	41.50	39.25	7.00
23,	34.00	44.00	35.00	37.00	10.00	35.25	42.25	38.25	38.50	7.00	36.00	41.00	39.00	38.75	5.00
24,	34.00	50.00	34.00	38.00	16.00	34.00	41.50	37.00	36.87	7.50	35.00	40.00	38.50	38.00	5.00
25,	34.00	54.00	36.50	40.25	20.00	33.00	45.75	43.50	41.43	10.50	34.50	43.00	44.70	46.50	10.00
26,	40.00	70.00	50.00	52.25	30.00	37.75	54.50	51.50	48.51	16.75	38.00	49.00	51.00	47.25	13.00
27,	44.00	80.00	50.00	58.00	36.00	43.75	59.75	56.50	54.12	16.00	42.75	55.50	55.50	52.31	12.75
28,	40.00	80.00	62.00	61.00	40.00	46.75	63.50	60.50	57.81	16.75	46.75	58.00	59.75	56.06	13.00
29,	58.00	83.00	60.00	65.25	25.00	52.75	65.50	61.00	60.06	12.75	52.00	62.00	60.50	58.75	10.00
30,	57.00	85.00	62.00	66.50	28.00	52.50	66.00	61.00	60.12	13.50	52.50	62.50	61.00	59.25	10.00
Sums,	1088.00	1468.00	1091.50	1170.20	1091.00	1008.50	1244.50	1141.00	1140.68	278.50	1021.50	1195 00	1155.50	1141.27	218.00
Mean,	39.93	56.27	41.98	45.00	41.98	38.79	47.87	43.88	43.87	10.52	39.24	45.98	44.44	43.87	8.19

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Soil Temperature Records for 1888. April.—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.	7 A.M.	2 P.M.	9 P.M.	Mean.	Range.
1,	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....
2,	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
3,	....	....	....	....	...	....	....	....	....	....	....	....	....	....	....
4,	....	....	....	....	...	....	....	....	....	....	....	....	....	....	..
5,	40.00	41.50	46.50	43.62	6.50	42.25	41.25	44.00	42.87	2.75	38.75	39.00	42.25	40.56	3.50
6,	46.75	51.50	46.75	47.98	4.75	43.50	44.50	45.25	44.62	1.75	41.00	41.00	41.25	41.12	0.25
7,	40.50	48.00	43.00	43.62	7.50	43.50	42.25	42.00	42.43	1.50	40.75	41.75	41.00	41.12	1.00
8,	37.25	45.50	42.75	42.06	8.25	41.50	41.50	42.50	42.00	1.00	41.75	41.50	41.50	41.56	0.25
9,	37.50	46.25	45.00	43.43	8.75	41.25	41.50	43.00	42.18	1.75	41.50	41.50	41.50	41.50	0.00
10,	42.00	41.75	43.00	42.43	1.25	42.50	42.00	42.00	42.12	0.50	41.50	41.50	41.50	41.50	0.00
11,	42.50	42.50	43.50	43.00	1.00	42.25	42.50	43.00	42.68	0.75	41.50	42.00	42.00	41.87	0.50
12,	41.50	42.50	41.00	41.00	1.50	41.50	42.25	42.50	42.18	1.00	42.00	41.75	42.00	41.93	0.25
13,	37.50	37.50	40.50	39.00	3.00	41.00	40.50	41.00	40.87	0.50	42.00	42.00	41.50	41.75	0.50
14,	39.00	41.00	39.50	39.75	2.00	41.00	41.00	41.00	41.00	0.00	41.50	41.50	41.50	41.50	0.00
15,	38.50	40.50	42.00	40.75	3.50	40.00	40.00	41.50	40.75	1.50	41.50	41.50	41.50	41.50	0.00
16,	39.50	41.25	42.00	41.18	2.50	41.50	41.25	42.25	41.87	1.00	41.50	41.50	41.50	41.50	0.00
17,	38.00	40.25	41.50	40.31	3.50	41.25	40.50	41.75	41.31	1.25	41.75	41.75	41.75	41.75	0.00
18,	40.50	42.00	42.75	42.00	2.25	42.00	41.75	42.75	42.31	1.00	41.75	41.75	41.75	41.75	0.00
19,	39.00	42.50	45.25	42.00	4.25	42.00	41.75	42.00	41.93	0.25	42.00	42.00	42.00	42.00	0.00
20,	40.50	40.50	40.00	40.25	0.50	42.50	41.50	42.00	42.00	1.00	42.00	42.25	42.25	42.19	0.25
21,	37.00	38.50	38.50	38.12	1.50	40.50	40.00	40.50	40.37	0.50	41.00	42.00	41.50	41.50	1.00
22,	36.50	38.00	41.50	39.37	5.00	39.50	39.00	40.50	39.87	2.50	41.50	41.50	41.50	41.50	0 00
23,	38.00	40.00	40.00	39.50	2.00	40.50	40.25	41.00	4 .68	0.75	41.50	41.50	41.50	41.50	0 00
24,	37.00	38.50	40.00	38.87	3.00	40.00	39.50	40.50	40.12	1.00	41.50	41.50	41.50	41.50	0.00
25,	3 .(0	39.75	44.00	41.18	7.00	40.00	39.75	41.50	40.68	1.75	41.25	41.50	41.50	41.43	0.25
26,	40.00	45.00	49.00	45.75	9.00	41.50	42.00	44.50	43.12	3.00	41.50	41.75	42.00	41.81	0.50
27,	43 00	49.(0	54.00	50.00	11.00	44.75	44.75	47.00	45.87	2.25	42.50	43.00	42.50	42.62	0.50
28,	47.75	52.50	57.00	53.56	9.25	47.50	47.50	50.(0	48.75	2.50	44.00	44.50	45.00	44.62	1.00
29,	52.00	56.50	58.50	56.37	6.50	50.50	51.00	52.50	51.62	2.00	45.50	46.50	46.50	46.25	1.00
30,	53.00	57.(0	59.(0	57.00	6.00	52.50	52.00	54.00	53.12	2.00	47.50	48.00	48.00	47.87	0.50
Sums,	1061.75	1139.75	1166.50	1122.05	121.25	1106.75	1101.75	1130.50	1117.32	35.75	1090.50	1096.00	1098.25	1095.70	11.25
Mean,	40.84	43.84	44.87	43.54	4.66	42.57	42.37	43.48	42.97	1.37	41.94	42.15	42.24	42.14	0.43

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Soil Temperature Records for 1888. May.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A.M.	2 P.M.	9 P.M.	Mean.	Range	7 A.M.	2 P.M.	9 P.M.	Mean.	Range	7 A.M.	2 P.M.	9 P.M.	Mean.	Range
1,	53	54	42	47.8	12	55	53	47.8	55.9	7.3	55	53	49	51.5	6
2,	40	55	36	41.8	19	42	49.5	46.5	46.2	7.5	48.5	48.5	48	47	5
3,	38	60	60	54.5	22	39.5	52	52	48.3	12.5	41	49.8	49.8	47.6	8.8
4,	50	68	52	55.5	18	46.5	59.8	54.5	53.9	13.3	46	57	55	51	11
5,	51	64	50	53.3	12	51.5	55.5	52.5	53	3	51.5	54.8	52.5	53.8	3.3
6,	56	62	56	57.5	8	48.5	60.5	56.5	55.5	12	37.8	57.8	56.5	52.1	20
7,	50	72	54	57.5	22	48	61.5	56	55.7	12.5	48.5	58	57.3	55.2	9.5
8,	50	59	52	40.3	9	50.5	54.5	53.5	53	4	50.3	53	53.5	52.5	3.3
9,	54	74	60	62	20	53.3	66.5	60	59.9	13.3	52.5	62.5	60	58.8	10
10,	62	75	61	64.8	14	59.5	68.8	62	63.1	9.3	58.3	65.5	62	61.9	6.3
11,	64	67	62	63.3	5	61	64	61.5	63	3	59.5	62.5	64	62.5	5.5
12,	63	62	56	59.3	7	60.3	64.5	59	60.8	5.5	60	63	60	60.8	3
13,	50	64	44	50.5	20	51	59.3	53	61.1	8.3	52	59	56	55.8	7
14,	50	56	44	48.5	12	49	55.8	49	50.7	6.8	48.5	54.5	51	51.3	6
15,	42	48	40	42.5	8	43.5	47.5	46	45.8	4	45	48.5	47.5	47.1	3.5
16,	44	52	39	43.5	13	43	49.8	44.5	45.9	5.3	45.5	49	47	47.1	3.5
17,	42	60	49	50	18	39.5	52	51.5	50.1	12.5	40.5	51	52	48.9	10.5
18,	46	51	53	50.7	7	48	50.5	53	51.1	5	48.5	50	52.5	52.1	4
19,	55	59	44	50.5	15	52.5	56.5	49.5	52	7.5	52	55	51.5	52.5	3.5
20,	46	60	46	49.5	14	44	54.5	51	50.1	10.5	45	53	52	50.5	8
21,	46	66	52	54	20	48	58.8	55.8	53.8	13.8	46	57	57	54.8	11
22,	50	68	52	55.5	18	49	60	55.5	55	11	49.5	57.8	56	54.8	8.3
23,	52	64	56	57	12	51	59	56	55.5	8	51	57	56	55	6
24,	55	60	56	56.8	5	54.5	58.5	57	56.8	4	54.5	57.5	57	56.5	3
25,	58	62	58	59	4	56	60.8	57.5	55.4	4.8	55.5	59	57.5	57.6	3.5
26,	59	67	58	60.5	9	57	62.5	59.4	59.4	5.5	56.5	59	59	58.4	2.5
27,	57	76	66	66.3	19	55.5	68.5	64	78	18	54.5	65.5	62	62	11
28,	65	81	62	67.5	19	62.5	72	65	66.1	9.5	61.5	66.5	65	65	7
29,	68	78	64	68.5	14	63	70	61.5	63.9	8.5	61	67.5	61	62.6	6.5
30,	64	73	64	66.3	9	63.5	67.5	64.5	65	4	65	66.5	64.5	65.1	2
31,	64	64	60	62	4	61	65.8	61.5	62.4	4.8	60.5	65	62	61.4	4.5
Sums,	1,644	1,979	1,648	1,717.2	408	1,605.6	1,889.4	1,717.0	1,749.57	240.0	1,596.4	1,783.7	1,734.1	1,714.8	202.0
Means,	53.03	63.84	53.16	55.37	13.16	51.79	59.33	55.39	56.46	7.74	51.49	57.60	55.94	55.31	6.51

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Soil Temperature Records for 1888. May—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A.M.	2 P.M.	9 P.M.	Mean.	Range	7 A.M.	2 P.M.	9 P.M.	Mean.	Range	7 A.M.	2 P.M.	9 P.M.	Mean.	Range
1,	55.5	53.5	51.5	53	4	54.5	53	52	52.9	2.5	48	49	49	48.8	1
2,	46.8	47.5	49.5	48.3	2.8	50	49	49.5	49.5	1	49	49	49	49	0
3,	44	47	47	46.3	3	48	47	47.5	47.5	1	49	48	48	48.3	1
4,	47	57.5	53.5	52.9	10.5	48.5	48.5	50	49.3	1.5	47.5	47.5	47.5	47.5	0
5,	51.5	53	53.5	52.9	2	50.5	50.8	50.5	51.2	1	47.5	48	48	47.9	0.5
6,	49	52.5	55.5	53.1	6.5	51	51	52	51.5	1	48.5	49	48.5	48.6	0.5
7,	50	54.5	57	54.6	7	51.5	51	42	46.6	9.5	49	49.5	49	49.1	0.5
8,	52.3	52	53	52.6	1	52.8	52	52	52.2	0.8	49.5	49.8	49.8	49.7	0.3
9,	52	56.8	59	56.7	7	52	52	59	55.5	7	49.8	49.5	50.5	50.1	1
10,	57.5	60.5	61	60	3.5	56	55.5	57	56.4	1.5	51	51	51.5	51	0.5
11,	59	60	60	59.8	1	57	57	57.5	57.3	0.5	52	52.5	52.5	52.4	0.5
12,	59	61	60	60	2	57	57.5	58	57.6	1	53	53	53	53	0
13,	52.8	58	57.5	56.4	5.3	56.9	56	56.5	56.4	0.8	53.5	53.5	53.5	53.5	0
14,	51	53	52	52.5	2	55	54	54	54.3	1	53.5	53	53	53.1	0.5
15,	48	48.5	49	48.6	1	52.5	51.5	51	51.5	1.5	52.5	52.5	51.5	52	1
16,	47	48.8	49	48.4	2	50.5	49.8	50	50.1	0.8	51.3	51	50.3	50.7	1
17,	48.5	48.5	52	49	3.5	49	48.5	50	49.4	1.5	50.5	50	49.5	49.9	1
18,	49.5	49.8	52	50.8	2.5	49.5	50	51	50.4	1.5	49.5	50	51	50.4	1.5
19,	51.5	53	53	52.6	2.5	51.5	51.5	52.5	52	1	50.5	50.5	51.5	50.5	0
20,	47	50.8	51	51.4	7	51	50.8	52	51.3	1.8	50.5	50.5	50.5	50.5	0
21,	48	53.5	57	53.9	9	51.5	51.3	53.5	52.4	2.3	50.5	50.5	50.8	50.6	0.3
22,	51.5	55	56.5	54.9	5	54.3	53	54	53 8	1.3	51	51.3	51.5	51.3	0.5
23,	51	54.3	55.5	54.1	4	54.5	53	55	54.4	2	51.5	51.8	52	51.8	1
24,	54	55.5	56	55.4	2	55	55	56	55.5	1	51.5	55	53.5	54.1	3.5
25,	55	54.5	57	54.4	2	55	55	55.5	55.3	0.5	53	52.5	53.5	53 1	1
26,	56	57	58.5	57.5	2.5	55.5	55.5	56	55.8	0.5	53	53	53	53	0
27,	55	60.5	62.5	60.1	7.5	53.8	56	56	56.9	2.3	53.3	53.5	53.5	53.4	0.3
28,	60.5	63.8	64.5	63.3	4.5	58.5	58.8	60.5	59.6	2	54	54.5	55	54.6	1
29,	61	64.5	61.5	62.1	3.5	60.3	60.5	60.5	60.4	0.3	54.5	56	56.5	54.1	1
30,	61.5	63.5	64	63	1	61	60.5	61	60.9	0 5	56.5	57	54.5	55.6	2.5
31,	61	63	62.5	62.8	2	60.5	61	61	60.9	0.5	57	57	57	57	0
Sums,	1,681.4	1,712.3	1,735.5	1,709.9	124.1	1,666.5	1,656.5	1,681.8	1,668.6	51.4	1,592.4	1,598.9	1,598.0	1,596.6	21.9
Means,	52.62	55.23	55.98	54.96	4.03	53.76	53.43	54.25	53.82	1.66	51.37	51.57	51.53	51.50	.70

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Soil Temperature Records for 1888. June.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	56 00	68 00	48 00	55 00	20 00	56 00	60.50	26.50	57 37	4 50	57.00	60 50	59 00	58 37	3 50
2,	52.00	54 00	46 00	49 50	8.00	53 50	56 50	52 00	53 50	4.50	53.50	57.50	55.00	55 25	4 00
3,	51 00	66.00	50.00	54 25	16.00	48 50	59.00	56.00	54.87	10 50	48 00	58.00	57 50	55 25	10 00
4,	52 00	73.00	54 00	53 25	21 00	49 00	64 50	60 00	58 37	15 50	49 00	62 50	60 75	58 25	11.75
5,	58 00	79.00	66 00	67 25	21.00	53 00	66 00	62 50	61 00	13 00	53.00	63 75	63.00	60 69	10 75
6,	69 00	86 00	66 00	71 75	20 00	60 00	73 50	69 00	67 87	13 50	58 75	69 00	68 50	66 19	10.50
7,	56 00	60.00	54 90	56 00	6 00	58 25	50.00	58 50	58 31	1 75	59.00	60 50	56.00	58.87	2 50
8,	56 00	78 00	56 00	63.50	22 00	55 75	69 75	64 50	61 12	9 75	55.50	66 50	66 00	63 50	11 00
9,	66 00	82.00	68 00	71 00	16 00	59 25	72 50	67 00	66.42	13 25	58 75	69 75	67 50	65 87	11 00
10,	70 00	88 00	68 00	72 25	15 00	64.50	74 00	69 50	69 62	9 50	64 50	70 25	69 50	68 44	5 75
11,	65 00	62.00	52 00	57 50	18.00	63 00	62 00	58 50	59 50	6 50	63 00	63 00	58 50	60 50	4 50
12,	56.00	73 00	52 00	58 25	21 00	52.50	67.00	61 50	60 62	14 50	53 00	64 50	63 50	61 12	11.50
13,	64 00	76.00	66 00	73 00	12 00	55 50	68 50	64 00	63 00	13 00	55 50	66 00	64 50	62 62	10 50
14,	69 00	86.00	70 00	73.75	17 00	63.00	74 50	71.50	70.12	11 50	61.50	70 50	71.25	68 62	9 75
15,	74 00	90 00	69.00	75.50	21 00	66 00	88 00	72 50	74 75	22.00	64 50	74 25	72 50	70 93	9 75
16,	76 00	91 00	70 00	76 75	21 00	69 00	79.25	74 50	74 31	10 25	67 50	76 50	74 75	72.37	9 00
17,	72 00	90 00	70.00	75 50	20 00	66 00	82 00	70.50	75 25	18.00	66 00	78 00	77 00	74 50	12.00
18,	76 00	96.00	75.00	80 50	21 00	69.00	85 00	77 00	77 00	16 00	68 50	81 00	79.00	76.87	12 50
19,	68 00	88 00	66.00	72 00	22 00	66 00	81 00	75 00	74 25	15 00	67.00	78 50	76 50	77 12	11.50
20,	72 00	92.00	70.00	76 00	22 00	67 50	81.75	77 50	76.08	14 25	67 50	79 50	78 00	75 75	12.00
21,	75.00	97.00	70 00	78.00	27.00	70.00	86 75	73 50	75 93	16 75	69 75	82 00	75.00	75 44	12 25
22,	75 00	90.00	74 00	78 25	16 00	71 00	81 00	77 00	76.50	10 00	70 00	78 00	77.00	75 50	8 00
23,	80 00	72 00	68.00	72 00	12 00	73 50	76 50	70 50	72 75	6.00	72. 0	76 50	71 50	72 83	5 00
24,	72 00	86 00	68 00	73.50	18 00	72 00	80.50	70 50	73.38	10 00	69.75	77 25	72 00	72 25	7 50
25,	72 00	84.00	67 00	73 75	17.00	68 50	73 00	70 00	70 38	4 50	68 00	72.00	71 50	70 75	4.00
26,	70 00	81 00	60 00	67.75	21 00	68.50	73 50	63 50	67.25	10 00	63 25	72 00	66 50	68 31	5.50
27,	65.00	76 00	62 00	66 25	14 00	62 50	72 50	64.50	66 00	10.00	62 50	70 00	66 00	66 12	7 50
28,	56 00	63 00	54 00	56 75	9 00	60 00	62 75	56 00	58 69	6.75	62.50	63.00	57.50	60 12	5.50
29,	57 00	60.00	58 00	58 25	3.00	59.00	60 00	59 50	59 50	1 00	61 00	60 50	60 00	60. 8	1.00
30,	60.00	80 00	67.00	63 50	20.00	59 50	69 50	63.50	64 00	10.00	59.50	67.00	65.00	64 12	7.50
Sums,	1,960 00	2,362 00	1,884 00	2,049 50	522 00	1,860 75	2,148.25	1,984 50	1 997.70	321 75	1.855.25	2 068.25	2,022 25	2 038 45	257 50
Means,	65 33	78.73	62 86	68 31	17.40	62 02	71.61	66 15	66.59	10 72	61.84	69 61	67.41	67.95	8 58

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Soil Temperature Records for 1888. June—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	59 00	60 00	51 00	55 25	9 00	60 00	59.50	61.00	60.33	1.50	57 00	58 00	57 00	57 25	1.00
2,	56 50	57 50	57 00	57 00	1 00	58 75	58 00	58.00	58 19	0 75	57 00	58 00	56 50	57.00	1.50
3,	51 50	56 00	58 00	55.37	6 50	56 50	55.50	57.00	56 50	1.50	51 50	56 00	56.50	54 62	4.50
4,	52 50	58 50	61 00	58 25	8 50	66 50	56.00	58 00	59 62	10 50	55.50	55 50	55.50	55 50	0 00
5,	55 00	60.25	62.50	60.08	7.50	57 50	57.25	59.00	58.19	1.75	55.50	55 50	55.75	55 62	0 25
6,	58 75	64.00	66.50	63 94	7 75	59.00	59.25	61 50	60.31	2 50	56 00	56 50	56 50	56 38	0.50
7,	61.00	60 50	59 00	59.88	2.00	61.25	60.25	59 50	60 13	1.75	57.00	57 25	57 00	57.00	0.25
8,	56 50	62 00	65 25	62 25	8 75	58 50	58 50	60 75	59 62	2 25	57 00	57.00	57.00	57.00	0 00
9,	59 50	64.75	67 00	64 50	7 50	60.50	60 50	62 50	61.50	2.00	57 50	57.50	57 50	57 50	0.00
10,	63 75	66.25	68 00	66 50	4 25	62.50	62 50	63.50	63 00	1.00	58 00	58 50	58 50	58 38	0.50
11,	63 50	63 50	60.75	62 12	1 75	62 50	62 50	62 00	62 25	0 50	59 00	59.00	59 00	59 00	0 00
12,	55.50	61 00	64.00	61.12	8.50	59.50	59 00	61.00	60.12	2 00	59.00	58.50	58 00	58 38	1.00
13,	57 50	62 00	64 00	61.88	6 50	60 25	59 50	61.00	60 44	1 50	58 50	58 50	58 00	58 25	0 50
14,	61 25	65 75	69 00	66 25	7 75	61.00	61 50	53 00	56 38	8.50	58.25	58 50	58 50	58 44	0.25
15,	64 00	69.50	71 00	68 88	7.00	63 50	63 50	65 75	64 62	2 25	59 00	59.50	59 50	59.38	0 50
16,	67 00	71.75	73 50	71 44	6.50	65 50	66.00	67.75	66.75	2 25	60 25	61 00	61 00	60 81	0 75
17,	68 50	73.00	76 00	72 83	9 50	67.00	67 00	69 50	68 25	2 50	61 50	62 50	62 50	62 25	1 00
18,	69 00	75 00	77 75	74 88	8.75	69 00	68 50	71 50	70 12	3 00	61 00	63 50	63 50	64.12	2 50
19,	69 00	73 75	71.50	71 44	4 75	70 00	69.25	71 50	70 58	2 25	64 00	64.50	64 50	64 33	0 50
20,	69 00	75.00	77 00	74 50	8 00	70 25	70 00	71.50	70.81	1.25	64 75	65.00	65 00	64 94	0 25
21,	70 50	76 50	75.00	74.25	6.00	71 00	70.50	72.00	71 38	1 50	65 50	66 00	65 50	65 62	0.50
22,	70 50	74 00	73 00	74 12	5 50	70.50	70.50	71 50	71.00	1 00	66 00	66 00	66 00	66 00	0.00
23,	71.75	75 50	72 50	72 94	3.25	71.25	71 00	71.50	71 31	0.50	66 00	66.00	67 00	66.50	1 00
24,	69 50	73 75	73 00	72.31	4.25	70.00	70.00	71.00	70 50	1.00	66 50	66 50	66 50	66.50	0.00
25,	68.75	70 50	74.00	70 81	3 25	70.00	69 50	70 00	69.88	0 50	66 00	66 00	66 00	66 00	0 00
26,	68.50	70 00	67 50	68 38	2.50	69 25	68.50	69 00	68 94	0 75	65.00	65 75	65 50	65 69	0 50
27,	64 00	68 00	67 00	66 50	4 00	67.50	67 00	67 00	67.12	0 50	65 50	65 50	65 50	65 50	0 00
28,	64 50	63 50	59 50	61 75	5 00	66 50	65 25	63.00	61 44	3.50	64 50	64 00	63 50	63 88	1 00
29,	62 00	60 50	61 00	61 12	1.50	65 00	62 50	62 50	63 12	2 50	64 00	63 50	62 50	63 00	1 50
30,	60.00	64 00	65 50	63.75	5 50	62 00	62 00	63 50	62.75	1.50	62 00	62.00	61 50	61 75	0 50
Sums,	1 886.15	1,995.75	2,008 75	1,974 12	171 50	1,931.50	1,910 75	1,936 25	1,928 19	64 75	1,820 25	1.831 00	1,825 75	1,826 70	20 75
Means,	62.87	66.52	66 96	65 80	5.75	64 38	63 69	64 54	64 27	2.12	60.67	61.33	60.86	60.89	.69

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Soil Temperature Records for 1888. July.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	64.00	73.00	54.00	61.25	19 00	60.50	64 25	58 25	60 81	6 00	60.50	68.75	61.50	61.81	8.25
2,	60 00	76 00	58 00	63 00	18.00	57.00	66. 0	61. 0	61.25	9.00	56 50	64.00	62.50	61 38	7.50
3,	62 00	80 50	62.00	66 63	18 50	58 50	73.00	65.00	65 38	14 50	58.00	70 00	66 75	65.38	12 00
4,	70 00	90 00	70 00	75 00	20 00	64 25	77.50	71.00	70 94	13 25	62 50	72 50	71 00	69.25	10.00
5,	72 00	84 00	70.00	74 00	14 00	69.00	79.00	69 50	71.75	10.00	67.50	75.50	71.5.	71.75	7.50
6,	68 00	87 00	63.00	72 75	19 00	63.00	74 50	68.75	68.75	11.50	62 50	71.50	70 00	68 50	9 00
7,	75 00	91 00	68 00	75.50	23 00	69 50	79 50	67.00	70 75	12 50	68.00	75 50	69.50	71.62	7.50
8,	68 00	85 00	63 00	71.75	19 00	62 00	77.00	7 .00	69 75	15 00	62.50	72.00	71. 0	69.12	9.50
9,	68.00	68 00	64 00	65 50	4 00	63 00	69 00	65 00	66 75	4.00	68.00	70.00	66 50	67.75	3 50
10,	62 00	82 00	66 00	69.00	20.00	64.00	75 00	68 00	68.75	11 00	64.00	72 50	69.50	68.88	8 50
11,	68 00	84. 0	74.00	75 00	16.00	62 50	75 00	70.00	69 38	12.50	62.50	72 50	70.00	71 25	10. 0
12,	68.00	56 00	50 00	56 00	18 00	61 50	59.50	57.50	59 00	4.00	63.00	62.75	6 .00	61.44	8.00
13,	5 .00	71. 0	59.00	6 .00	2 .00	54 00	63.50	57 00	57 87	9 50	54.50	64 50	60 00	59 25	9 00
14,	60 00	78 00	64.00	68.50	18.00	56.50	67.50	63 50	63 75	11 00	56 50	68 00	67.00	64.12	10.50
15,	64.00	78. 0	54 00	62 50	24 00	61.00	69.00	61 75	63 38	8 00	60.50	67 50	65.00	64 50	7.00
16,	58 00	80.00	58. 0	63 50	22.00	57.25	71 00	61.00	62.56	13 75	57.50	68.00	62.75	62 75	10.50
17,	64.00	78. 0	60 00	65 50	18.00	59 50	70.50	63 50	64 25	11.00	59 00	68.00	65.00	64 25	9 00
18,	65 00	64.00	64 00	64.25	1.00	60 75	66 00	64.50	63 94	5.25	61 50	64.50	64.50	63 75	3.00
19,	66.00	67.00	63 00	63 25	7.00	65.50	73 00	64.50	66 88	8 50	65 00	70 75	66 00	66.94	5.75
20,	63 00	74 00	60.00	64.25	14 00	63.00	70.50	63.00	64.88	7.50	62 50	68 50	65 75	65.62	6 00
21,	63 00	78. 0	58 00	64 25	20.00	60.25	71.00	64.00	64 81	10 75	60.00	69.00	68 50	65.50	9 00
22,	66.00	81.00	66 00	69.75	15.00	62 00	72 50	63 00	62 62	1 .50	61 50	70 50	69.50	67.75	9 00
23,	70 00	81 00	68 00	71.75	13.00	65 00	76. 0	69 50	70 00	11. 0	64 00	73.50	70 25	69.50	9.50
24,	72 00	83 00	56 00	66 75	27.00	67 00	74 00	62.00	66 25	12.00	66 .0	72. 0	65.50	67 25	6 50
25,	6 .00	82 00	64 00	67.50	22.00	57.50	74 00	66.50	66 12	16 50	58.50	71.00	68 50	66.03	12 50
26,	64 00	86.00	64 00	69 50	22.00	61 50	75 00	63 50	98 83	13.50	61 50	72 0	7 .00	68.38	10 50
27,	64 00	80 00	60.00	66.00	20.00	66 00	75.00	66 .0	68.25	9.00	65 50	73 00	60.00	64 38	12 00
28,	60.00	82 00	60 00	65.50	22.00	62 00	74 00	63 50	44 75	12 .0	62.50	71 50	67 50	67.25	9 00
29,	66 00	82 00	64 00	69.00	18 00	63 50	75 00	67 00	68 12	11.50	62.50	72 00	68 50	67.88	9.50
30,	68 00	82.00	68 00	71.50	14 00	66 50	76.50	70 00	70.75	10.00	65 50	73.00	71.00	70 12	7 50
31,	70.00	90.00	74 00	77.00	20.00	68.00	79.00	73 00	73 25	11.00	67.00	75.50	73.25	72.38	8.00
Sums,	2,017 00	2,551.50	1,953 00	2,093 63	545.50	1,936.50	2,242 25	2,031 25	2,034.07	325 50	1,927.50	2,170 25	2,076.25	2,065 73	254.00
Means,	65.06	82.30	63 00	67.53	17 59	62.47	72.33	65.52	65.61	10.50	62.18	70 01	66 97	66 63	8.19

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Soil Temperature Records for 1888. July—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	A. M.	2 P. M.	9 P. M.	Mean.	Range.
1.	62 00	61 75	63.50	62 44	1 50	63 50	63 00	63 25	63 25	0 50	61 50	61 50	61.50	61 50	0.00
2.	59 00	62 25	65 50	62 81	7 50	63 00	61 50	63 00	62 33	1 50	61 50	61.50	18 50	61.50	0 00
3.	59 50	66 00	67 25	65 00	7 75	62 50	62.50	64 00	63 25	1.50	61 50	61 50	61 50	61 50	0 00
4.	62 50	68 50	70 00	67 75	7 50	64.00	64 00	66 00	65 50	2 00	62 50	62 00	62 00	62 12	0.50
5.	66 75	70 50	71 00	69 81	4.25	66 00	66.00	67 50	65 75	1 50	62.50	62 50	62 00	62 75	0.50
6.	64 50	69.75	71 00	69 81	6 50	65.50	66 00	67 50	66 33	1.50	63 25	63 50	63 50	63.44	0.50
7.	67.50	67 50	69 00	68 25	1 50	64 50	67 50	69 00	67 25	5 50	63 50	64 00	64 00	63 88	0.50
8.	65 00	69 50	71 75	69.50	6 75	67 75	67.00	68 50	67 91	1 50	64 50	64 75	64 50	64 58	0 25
9.	64.00	69.50	67.50	68 12	2 0	68 00	68 00	68 00	68 00	0.00	64 50	64 75	65 00	64 81	0 50
10.	64 50	69 00	71 00	68.33	5 50	66.50	66 50	67 50	67 00	1 00	64 50	64 50	64 50	64 50	0 00
11.	64.50	69 00	70 00	68 33	5 50	67 00	66.50	68 00	67 33	1 50	64 50	64 50	64 50	64 50	0 00
12.	65.00	65 00	61.00	63 25	5 00	67 50	68 00	64 00	65.33	3 50	64 50	64 50	64 50	64 50	0 00
13.	59 00	61 00	62 50	61. 0	4 50	63 00	62.00	63 00	62 75	1 00	64. 0	63 50	63 00	63 38	1 00
14.	58 50	63 50	65 0	63 50	7 50	62 0	62 00	63.00	62 50	1.00	62 50	62.50	62 00	62 25	0 50
15.	61 50	65 00	66 50	64 88	5 00	63.50	63 50	64 50	64 00	1 00	62 00	62 00	62 00	62 00	0 00
16.	60 00	64 50	66 00	64 12	6 00	63.50	63 00	65 00	64 12	2. 0	62 50	62 50	62 50	62 50	0.00
17.	61.00	65 00	66 00	64 50	5 00	64 00	63 50	64.50	64 12	1 00	62 50	62 50	62 50	62 50	0 00
18.	62 50	63 50	64 00	63 50	1 50	64 00	65 50	63.50	64.12	2 00	62 50	62 50	62 50	62 50	0 00
19.	64 50	67 0	68 50	66 12	2 50	64 00	64 00	65.50	64.75	1 50	62 50	62 50	62 50	62 50	0 00
20.	63 25	64 00	67 00	65 31	3 75	64 50	64.00	65 00	64 62	1 00	63 50	62.50	62 50	62 50	0 00
21.	62 00	63.00	63 00	65. 0	6 00	64 50	61 00	66 00	65 12	2 00	62 50	62 75	62 50	62 58	0.25
22.	62 50	67 50	70 00	67 50	7.50	65 00	64 75	66 25	65 56	1 50	63 0	63 00	63 0	63 00	0 00
23.	65 50	71 00	70 25	69 25	5.50	63 00	66 50	67 00	66.63	1 00	63 25	63 50	63 50	63 44	0 25
24.	66 00	69.00	68 50	68 00	3.00	65 50	68 50	67 50	67 0	1 00	63 50	64 0	64 00	63 88	0 50
25.	62 00	67 50	69 50	67 12	7.50	66 00	65 50	67 00	66 38	1 50	64 00	64 50	64 00	64 12	0 50
25.	61.50	72 00	70.00	63 33	10.50	63 00	66 0	67 50	66 75	1.50	64 50	64 50	64 00	64 25	0 50
27.	63 50	69 00	69 00	68 88	9 00	67.00	67.00	67 0	67.00	0.00	64 50	64 50	64 50	64 50	0 00
28.	64 50	69 00	69 50	68 12	5 00	67 00	64 50	68 00	67 33	1 50	64 50	64 50	64 50	64 50	0 00
29.	64 00	69 50	69 00	67 83	5 00	64 50	65 50	68 00	67.25	1 50	64.75	64 75	64 50	64 68	0 25
30.	65.00	69 50	71 50	68 63	6 50	67 50	67 00	68 50	67 88	1 50	64 50	65 00	65 00	64 83	0 50
31.	69 00	71.50	73 25	71 50	5 25	68 25	68 50	69.75	68.06	1.50	65 00	65 50	65 50	65.38	0 50
Sums,	1,976 50	2,081 25	1,102 40	2,062 45	168 75	2 023 00	2,020 75	2,052 75	2,037 93	45 50	1,933 75	1,935 50	1,934 50	1,934 94	7 50
Means,	63 76	67.13	35 56	66 53	5.38	65 28	65.15	66.21	65 74	1.50	63 34	63.42	63 37	63.38	.24

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Soil Temperature Records for 1888. August.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	69 00	85.00	63.00	70 00	22 00	69 75	77 00	67 00	75 19	10 00	70.00	74 50	70 00	71.13	4 50
2,	56 00	87.00	64 00	67 75	31 00	58 00	75 50	63 00	67 28	17.50	61 00	73 25	69.50	68.30	12 25
3,	70 00	90 00	70 00	75 00	20 00	65 50	78 50	72 75	72 28	13 00	66.00	74 50	73 5	71 88	8 50
4,	79 00	95 00	68 00	77.50	27 00	72.00	84 00	72.50	73 25	12.00	70 00	79 50	74 00	74 38	9.50
5,	78 00	82 00	70 00	75 00	12 00	73 50	80 50	74 00	75 50	7 00	71 50	77 00	74 50	74 38	5 50
6,	74 00	88 00	74 00	77 50	14 00	73 00	80.25	74 50	75 40	7 25	72 00	78 00	75.00	75 00	6.00
7,	74 00	88 00	66 00	73 50	22 00	70 50	78 00	71.50	72 83	7 50	70 00	76 00	73 50	73 25	6.00
8,	76 00	94.00	74 00	77 00	20 00	70 25	82 25	74 50	73 33	12 00	69 00	78.00	75 00	74 25	9 00
9,	70 00	82.00	64 00	70 00	18.00	60 00	76 00	63 00	68 50	16 00	69 00	74 75	72 50	72.19	5.75
10,	65 00	80 00	60.00	66 25	20.00	61 25	74 00	67 00	67 31	12 75	62 50	72 50	70.50	69 00	10 00
11,	62 00	78 00	62 00	65.00	16 00	61 50	75 00	63 00	68 33	12 50	64 00	72 00	69 50	68 75	8.00
12,	70 00	77 00	60 00	66 75	17 00	69 50	76 00	65 00	69 83	11 00	63 00	75 25	68 75	70.19	7.25
13,	60 00	63 00	54 00	59 25	11 00	61.50	64 50	59.50	61 25	5.00	63 00	65 00	62 50	63.25	2 50
14,	57 00	76 00	53 00	61 25	19 00	55 50	67.50	62 00	61 75	12 00	57 50	66 50	65 00	63 50	9 00
15,	60 00	82.00	60 00	70 50	22 00	59.50	73.00	63 75	67 50	13 50	61 00	79 25	69 00	69 56	18 25
16,	76 00	88 00	74 00	78 00	14 00	69 50	79 50	73 50	74 00	10.00	67 50	75 25	73 50	72 42	7 75
17,	64.00	80 00	70 00	71 50	14 00	69.00	74 00	71 50	71.50	5 00	69 00	71 50	72.00	71 12	3.00
18,	66 00	77.00	64 00	67.75	13 00	67 00	73.50	67 50	68 88	6 50	67.00	72 50	69 00	69 38	5.50
19,	66 00	83 00	64 00	69 25	19 00	61 50	74 00	67 50	67.63	12.50	62 00	71.25	68 50	67 56	9 25
20,	62 00	84 00	67 00	70.00	22 00	63 00	77 50	69 50	69 88	14 50	64 00	74 00	70.00	69 50	10 00
21,	60 00	64.00	60 00	61 00	4 00	63 00	65 00	63 00	63 50	2 00	63 75	65 50	63 50	64 08	2 00
23,	58.00	64 00	56 00	58.50	8 00	60 00	61 00	58 00	59 25	3 00	61 50	62 50	60.00	61 00	2.00
23,	49 50	70 00	56 00	57 88	20 50	50.50	61 00	58 50	57 13	10 50	53 25	60 75	60.50	58 75	7.50
24,	59 00	79 00	60 00	64 50	20.00	55 00	66 25	61.75	61.19	11 23	56.50	64 50	63 50	62.00	8 00
25,	61 00	80 50	64 00	67.38	19 50	58 00	69 50	63 50	63 63	11 50	58 75	67 25	65 00	64 00	8 5
26,	64 00	85 00	70 00	72 25	21 00	59 25	73 50	63 25	67 31	14 25	59 75	70 25	68 50	66 75	10 50
27,	72 00	78 00	57 00	66 00	21 00	67 25	71 00	61 00	65 06	10.00	66 50	69 50	63 50	65.75	6 00
25,	49.50	70 00	57 00	58 38	20 50	52.25	65 75	59 50	59.25	13 50	55 25	64 75	62 00	61 00	9 50
29,	49 50	77 00	62 00	62 63	27.50	51 75	67 25	61 50	60 50	16 50	54 50	65 25	63 00	61 44	10 75
30,	56.00	82.00	60 00	64 50	28 00	55 00	71.50	64 75	64 00	16 50	57 00	68 50	66 00	64 38	11 50
31,	60 00	69.00	60.00	62.25	9 00	59 75	67.50	65 00	64 31	7 75	60.50	65.50	65.00	64 00	5 00
Sums,	1,994 50	2,479.50	1,978 00	2,105 02	571.50	1,944 00	1,259 75	2,068 25	2 089 25	334 25	1,971 25	2 204.75	2,115 75	2,102 02	238 75
Means,	64.34	79 98	63.80	67 90	18.43	62 71	40 63	66.71	67 41	10 78	63 59	71 12	63.25	67 80	7 70

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Soil Temperature Records for 1888. August—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	70 00	72 00	72 00	71.50	2.00	69 50	69.50	70 50	70 00	1 00	66 00	66 00	66 00	66 00	0 00
2,	65 00	70.50	71 00	69 38	6.00	69 00	68 00	69 50	69 50	1 50	66 25	66 50	66.00	66.16	0 50
3,	67.50	71.00	72.25	70 75	4.75	69.00	69.75	70 00	69 69	1.00	66 00	66 50	66 50	66 38	0.50
4,	69 75	74 25	75.00	73.50	5 25	69.75	70 00	71 50	70 69	0 75	66 50	67.00	67 00	66 83	0 50
5,	71 00	72 50	74 00	72.88	3 00	71.00	70 50	71 00	70 88	0.50	67 00	67 25	67.00	67.06	0 25
6,	72.00	74 50	75.00	74.13	3 00	71.00	71.00	72 00	71 50	1 00	67 50	67 50	67 50	67 50	0 00
7,	71.00	73 50	74 50	73.38	3 50	71 25	71 00	72 00	71 58	1 00	67 50	68 00	67 50	67 63	0.50
8,	69.50	74 00	75.00	73 39	5.50	71 00	71.00	72 00	71.50	1 00	68 00	68.00	68 00	68 00	0.00
9,	70 50	73 00	74 50	73 13	4 00	71.75	71 25	72 50	72 00	1.25	68 00	68 50	68 00	68 13	0 50
10,	65.50	70 00	72 75	70 25	7.25	70 50	69 50	71 00	70 50	1 50	68 25	68 50	68 00	68 19	0 50
11,	61.50	69.50	70 50	63.00	9 00	70.00	69 00	70.00	69 75	1 00	68 00	68.00	67 50	67 50	0 50
12,	68 00	71 50	70 00	69 88	3 50	69.25	69 00	70 00	69 56	1.00	67 50	67 50	67.50	67 50	0.00
13,	65.50	65 75	65.50	65 58	0 25	68 50	68 00	67 00	67 63	1 50	67 25	67 00	67 00	67 06	0 25
14,	61 00	65.00	66.50	64.75	5.50	66.00	65 00	56 00	60 75	10 00	66 25	66.50	65.50	65 61	1 00
15,	63 00	68.00	68 50	66 50	5.50	65 50	65.50	66.50	66 00	1 00	65 50	65.25	65 00	65 19	0 50
16,	67 00	71 00	72 00	70 50	5.00	67 00	67.00	78 50	72 75	11.50	65 00	65 00	65 00	65 00	0.00
17,	69.25	69.5	71 00	69 69	1 75	68 75	68.50	69 00	68 81	0.50	65.50	65 50	66.00	65 75	0.50
18,	68 00	70.50	69 75	69.50	2 50	68.50	68 25	68.75	68 56	0 50	66.00	66 00	66 00	66 00	0.00
19,	64.50	68.25	69.00	67.69	4 50	67.50	67 00	67.00	67 12	0·50	66 00	66 00	66 00	66 00	0.00
20,	65 75	69 50	70 25	68.94	4 50	67 50	67.50	68 50	68 00	1.00	65 50	65 50	65 75	65 63	0 25
21,	65 50	66 00	65.00	65.33	1.00	68 00	67.00	67 00	67.25	1 00	66.00	66.00	66 00	66 00	0.00
22,	63 00	63 00	63 00	63 00	0.00	65 50	65 00	65 00	65 13	0 50	65 50	65 00	64 50	64 88	1.00
23,	57.50	60 25	62 00	60.44	4 50	63 00	62.00	62.75	62 63	1 00	64 25	64 00	63 50	63 81	0 75
24,	58 75	62.50	64 25	62.44	5 50	62.50	62.00	63.50	62.88	1 50	63 00	63 00	62.75	62 88	0.25
25,	60.50	64 50	65.75	64 13	5 25	63 00	63 00	64.00	63 80	1 00	62.75	62 75	62 75	62.75	0.00
26,	61.50	66 25	68 00	65.94	6 5	63 75	63 50	65 00	64.31	1 50	62 75	63 00	63 00	62 94	0 25
27,	66 00	67 50	66 50	66.50	1.50	66 00	65 50	66 00	65 75	0 50	63 25	63 50	63 50	63.44	0.25
28,	59 50	62 75	64 00	62 56	4.50	64 50	63.25	64 00	63.94	1.25	63 50	63 75	63 50	63 56	0 25
29,	58 50	62 50	64 00	62 25	5 50	63 00	62.25	63 50	63 06	1 25	63.25	63 25	63 00	63.13	0.25
30,	59 75	64 50	66 25	64 19	6 50	63.00	62 50	64 00	63.38	1.50	62 75	63 00	62 75	62 81	0 25
31,	62 00	64.00	64 25	63 63	2.25	64 00	63.50	64 50	64 13	1 00	62 75	63 00	63 00	62 94	0.25
Sums,	2,017.75	2 114.50	2,143.00	2 103.76	129 25	2,088.50	2,075.75	2, 102 30	2,092.22	51 00	2 033.25	2 036 25	2,031.00	2,033.31	9 75
Means,	65 09	68 21	69.10	67.86	4 17	67.37	66 96	67.81	67.49	1.64	65 59	65 68	65 51	65.56	.31

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Soil Temperatare Records for 1888. September.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	63 00	74 00	62 00	65.25	12 00	61 50	69 00	63 50	64 38	7 50	61 75	67.00	64.50	64 44	5 25
2,	54 00	74 00	54 00	59 00	20 00	54.50	66 25	60 75	60 56	11.75	57 00	65.25	63 25	62 19	8 25
3,	53 00	71 00	60 00	61 00	18.00	55 00	65 50	61 50	60 88	10 50	57 00	63 75	62 25	61.31	6 75
4,	58.00	75 00	63 00	64 75	17.00	59 25	67 75	63 75	63.63	8 50	59 00	65 25	64 25	63.19	6 25
5,	58 00	74 00	54 00	60.00	20 00	58 75	65.75	60 00	61.13	7 00	60.00	65 50	62 50	62 63	5 50
6,	47 00	67.00	46.00	51.50	21 00	50.50	63 25	55 50	56.19	12 75	53 50	62 25	58 50	58.19	8 75
7,	48.00	53 00	52 00	51 25	5.00	50.00	55 50	53 50	53 13	5 50	52 00	56.50	55.00	54 63	4 50
8,	52 00	62 00	60 00	58 50	10 00	54 00	61 00	61.50	59 50	7.50	54 75	59 00	61 00	58 94	6 25
9,	64.00	80 00	65.00	68.50	16 00	61.00	71 50	65 50	65 88	10.50	60 25	67.50	65 50	64 69	7 25
10,	58.00	74 00	58 00	62 00	16.00	53.00	68.00	61 75	62 38	10 00	59 00	65.50	63.25	62 75	6 50
11,	56 00	69 00	58.00	60.25	13 00	57.50	64 75	60.25	60 69	7 25	58.75	63 25	61 50	61.25	4 50
12,	60.00	74 00	64 00	65 50	14.00	56 00	68.75	64 00	63 19	12 75	56 75	66 25	64 50	63 10	9.50
13,	54 00	65 00	48 00	53 75	17 00	54.75	58 00	52.00	54 19	6 00	57 00	59.00	55 00	54 00	4 00
14,	46 00	70.00	48.00	52.50	24 00	46 75	62 00	54 00	54 19	15 25	49 25	60 25	56 50	55.63	11 00
15,	49 00	65 00	60 00	58.50	16.00	49.00	61 75	59 00	57 19	12 75	50.50	60 00	59 00	55 00	9 50
16,	60 00	66.00	64 00	63 50	6 00	58 00	65.50	64.00	62.88	7 50	57 75	64 50	63 75	62 44	6.75
17,	59.00	62 00	62.00	61 25	3 00	58 50	68 50	61.75	61.38	5 00	59 25	62.50	61 75	61.31	3 25
18,	59.00	73.50	60 00	63.13	14.50	57.25	67.25	61 50	61 88	10 00	58.00	67.75	62 75	62 81	9 75
19,	53 00	76 00	58 00	62 50	18 00	57.25	66 50	61 50	61.88	9 25	58 50	65 25	62.50	62.19	6.75
20,	58 00	68.00	60.00	61.50	10.00	58.50	64 00	61 50	61.38	5 50	59 50	62.50	62 00	61.50	3.00
21,	54 00	63 00	49 00	55 00	19 00	54 75	61 25	55 75	56 58	6.50	56 25	61 00	58 00	58.31	4 75
22,	51.00	72.00	52.00	58 75	21 00	50 50	64 25	58 00	57 69	13 75	52.25	62 50	59.50	58 43	10 25
23,	50 00	71 00	58.00	59 25	21.00	51 00	63.50	58 25	57.75	12 50	52.00	62 00	60 00	58 50	10 00
24,	50 00	68 00	50.00	54 50	18 00	51.50	62 75	55.00	58 56	11 25	53 00	60 50	57.00	56 87	7.50
25,	43 00	56 00	46 00	49.00	10 00	51 50	56 50	51 75	52 87	5 00	52 00	56.50	54 00	54 12	4.50
26,	44.00	62 00	50 00	51 50	18 00	47 00	57 75	53 00	52.69	10 75	50 00	58 00	55 50	54.75	8.00
27,	50 00	66 00	47 00	52 50	19.00	51 00	57 00	50 00	52.00	7 00	52 00	58 50	52 50	53 37	4 50
28,	48 00	58 00	38.00	45 50	20.00	47 25	50 75	45.00	47.00	5.75	45.00	51 50	48 50	40 12	3 50
29,	40 00	46 00	38 00	40.50	8 00	42 00	49.00	43 00	44 25	7.00	44 00	49.25	46 00	46 31	5.25
30,	45.00	45.00	40 00	42.50	5.00	42.00	47 50	46.00	45 37	5.50	43 00	47.50	46 00	45 62	4.50
Sums,	1,594 00	2,004 50	1,624 00	1,811.13	449.50	1,604.50	1,865.75	1,722.50	1,731 57	287.25	1,639 00	1.834 00	1,766 25	1,747 59	169 00
Means,	53 13	61.81	54 13	63 71	14 98	53 48	62 19	57 41	57.48	8 91	54 63	61.13	58.87	58.12	66.33

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Soil Temperature Records for 1888. September—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	62 50	65 00	65 00	64.37	2 50	63.75	63 50	64 25	63 93	0 75	63.00	63 00	63 00	63 00	0.00
2,	60.50	63 00	64.50	63 12	4 00	63 50	62 75	63 75	63 43	1 00	63.00	63 00	62 75	62 88	0.25
3,	59 75	62 00	63.00	61 58	3.25	63 00	62.50	63.00	62 88	0 50	62 50	62.50	62 50	62 50	0 00
4,	60 50	63 00	64 50	63 12	4 00	62 50	62 50	63 00	62.75	0 50	62.50	62.50	62 25	62 38	0 25
5,	61 50	63 75	64 50	63.58	3 00	63 00	67 75	63 50	64 44	4.75	62.25	62.25	62 25	62 25	0 00
6,	58 00	60 50	61 00	60.12	3 00	62.50	61.50	62.00	62.00	1 00	62.25	62 25	62 00	62 13	0 25
7,	46 00	57 50	57 00	54 37	11 00	61 00	60 00	60.00	60 25	1.00	61.75	61 50	61 50	61 58	0 25
8,	55.25	58 50	60.00	58 43	4 75	59.00	59 50	59 50	59 37	0 50	61.00	60 50	60.00	60 37	1.00
9,	60 00	63 50	64 50	63.12	4 50	60.00	60.50	62 00	61 12	2 00	60 00	60 25	60 25	60 19	0 25
10,	61 00	63.00	64.00	63 00	3 00	62 00	61 75	62 50	62 19	0.75	60 50	61.00	61 00	60 87	0.50
11,	60.25	61 50	62.50	61.68	1 25	62 00	61.50	62.00	61 83	0.50	61.00	61 25	61 00	61 08	0 25
12,	59 00	63 00	63 00	62.00	4.00	61.50	61 25	62 50	61.81	1 25	6 .00	61.25	61 00	61 00	0 25
13,	59 75	59 50	58 50	59 08	1 25	62 00	61 25	61 00	61 31	1 00	61.00	60.75	60 25	60.66	0 75
14,	54 00	57.50	59 00	57.37	5 00	59 50	59 50	59 50	59 50	0 00	61.00	60.75	60 25	60 56	0 75
15,	54.00	57 75	59 00	57.43	5 00	59 00	58 25	59.00	58.81	0 75	61.00	60 00	59 75	59 88	0 25
16,	58.00	63.00	63 00	61 75	5 00	59 25	60.00	61.00	60 31	1 75	59 75	59 75	59 75	59 75	0 00
17,	60.50	61 50	61 75	61 37	1 25	61 00	61.00	61 25	61 12	0.25	59 75	60 25	60 25	60.12	0 50
18,	59 50	62 75	63.25	62.19	3 75	61 00	61 75	61 75	61.56	0 75	60 25	60.25	60.25	60 25	0 00
19,	60 50	63.00	63.25	62.50	2 75	61 50	61 50	62 50	62 00	1.00	60 50	60 75	60 75	60 69	0 25
20,	60 50	61 50	62 25	61.62	1 75	62 00	61 50	62 00	61 67	0 50	61 00	61.00	61 00	61 00	0 00
21,	59.00	60.50	60.00	59 87	1.00	61 50	61.00	61.00	61 12	0 50	61.00	61.00	60 75	60 88	0.25
22,	55 75	59 50	60 50	59 08	4 75	60.00	59 50	60 50	60 12	1 00	60 75	60 50	60 50	60 56	0 25
23,	56.50	59 50	60 50	59 25	4 00	60.00	59 50	60 25	60 00	0 75	60.25	60 25	60 00	60 12	0.25
24,	56.00	58 25	59 00	58 08	3.00	59 75	59.00	59 00	59.18	0 75	60.00	60 00	60 00	60 00	0 00
25,	55 50	56 50	56.50	56 25	1 00	59.00	58 50	57 50	58 12	1 50	59 50	59.50	59.50	59 50	0 00
26,	53 00	56 25	56 50	55 56	3 50	57 50	57 00	57 50	57 37	0.50	59.00	59 00	58 50	58.75	0 50
27,	54 00	55 75	55.00	54 92	1.75	57 00	56 75	57 00	56 93	0 25	58 50	58.50	58 00	58 25	0 50
28,	51 00	52.50	51 50	51 62	1 50	56 00	55 50	55 50	55 62	0 50	58 00	57 75	57.50	57.68	0.50
29,	47 50	49.50	49 00	48 75	2 00	53 50	53 00	53 50	53 33	0 50	57 00	56 50	56.25	56 50	0 75
30,	43.00	48.50	45.50	45 12	3 50	46.00	47 50	48.50	47 62	2 50	56.00	55.50	55.50	55 67	0 50
Sums,	1,702 25	1,785 50	1,797 50	1,770 58	100 00	1,799 25	1,797 00	1,806 25	1,801 99	29 25	1,814.00	1,813.25	1,808 25	1,810 86	9 25
Means,	56 74	59.51	59 91	59 02	3 33	59.97	59.90	60 21	60.06	.97	60 46	60.44	60.27	60.62	.31

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Soil Temperature Records for 1888. October.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	46 00	69.00	54 00	55 75	23 00	45 50	58 00	54 00	52.87	12 50	45.50	54 00	54 00	51 87	8 50
2,	48 00	55.00	36 00	43 75	19.00	48 75	53.00	42 50	46 71	10 50	49 00	51 50	46 50	48 37	5 00
3,	42 00	45 00	34.00	38.75	11 00	41.00	44 50	40 00	41.37	4 50	41 00	45.00	42.50	42 75	4 00
4,	40 00	58 00	44 00	46 50	18 00	40 00	50.50	44.50	44 75	10 50	40 75	48 00	46 00	45 18	7 25
5,	44 00	63.00	50 00	51 75	19 00	43 00	55 50	52 50	50 87	12 50	43.50	52 00	51.00	49.37	8 50
6,	52 00	56.00	50 00	51.00	6 00	50 00	55.00	51.50	52 00	5 00	49 00	54 00	52 00	51 75	5 00
7,	44.00	54 00	46 00	47.50	10 00	45 75	52 00	48 75	48 81	6.25	46 50	51 50	49 00	49 00	5 00
8,	46 00	48.00	38 00	42 50	10 00	46 00	49 00	41 00	44 25	8 00	47 00	49 00	44 50	46 25	4 50
9,	35 00	48 00	38 00	39 75	13.00	38 00	44 00	38 50	40 25	8.00	39 50	44.00	41 00	41 37	4 50
10,	38.00	51.00	38 00	41 25	13 00	38 00	49 00	42 00	42 75	11.00	38 50	47 50	44 00	43 50	9.00
11,	34 00	44 00	42 00	40.50	10.00	37.00	43 00	44 50	42 25	7.50	39.00	43.00	42 50	41 75	4 00
12,	40 00	46 00	40 00	41 50	6 00	41 00	46 50	43.00	43 37	5.50	42 00	45.50	43 00	43 37	3 50
13,	42.00	48 00	40.00	42.50	8.00	43 00	48 00	43 50	44 50	5 00	43 00	47.50	44 50	44 87	4 50
14,	44 00	48.00	42 00	44 00	6.00	44.50	47.00	43 50	44 62	3 50	44 00	46 50	45.00	45 62	2 50
15,	36 00	52 00	46 00	45 00	16.00	38.00	50 00	45 25	44 62	12 00	39 50	48 00	46 00	44 87	8.50
16,	47.00	62 00	44 00	49.25	18 00	46 00	63 50	46 50	50.62	17.50	46 00	51 50	47 50	48 12	5.50
17,	42 00	50.00	44 00	45 00	8 00	44 00	49.50	44 50	45 62	5 50	45 00	48 50	45 50	45 62	3 50
18,	45 00	52.00	40 00	44 25	12 00	43.50	49.50	43.50	45.00	6 00	45.50	48 25	48.50	47 68	3.00
19,	44.00	51.00	52 00	49 75	6.00	44.00	48.75	49 25	47.81	5 25	46.50	48.00	48 50	48 37	.0
20,	40.00	44 00	36 00	39 00	8 00	40 00	42 50	38 50	39 87	4 00	42 25	43 25	40 50	41 37	2.75
21,	36 00	42 00	28 00	33.50	14 00	36.00	40 50	34.50	36 37	6 00	37 50	40 25	37 50	38 18	2.75
22,	32 00	50.00	44 00	42 50	18.00	34 00	47 50	45 00	43 25	13 50	36 00	45 00	43.75	42 12	9 00
23,	42.00	50.00	48 00	47 00	8 00	42 50	48 50	48 00	46 75	6.00	42 50	46 50	47 25	45 87	4 75
24,	42 00	50.00	34 00	40 00	16.00	44 00	46 00	40 00	42 50	6 00	45 50	45.50	42.00	43 75	3.50
25,	38 00	64 00	40 00	45.50	26 00	37.00	53 75	44 00	44 68	16 75	38 50	50.25	45 00	44 68	11.75
26,	46 00	52 00	46 00	47 50	6 00	43.00	49 00	46 25	46 12	6.00	43 25	47 50	46 50	45 93	4 25
27,	46.00	52.00	50 00	49 50	6 00	45 75	50 50	50 00	49.06	5 25	45 75	49 00	49 00	48 19	3 25
28,	49 00	48.00	42 00	46.25	7.00	49 00	47 50	41 00	44 62	8.00	49.00	47 50	43 00	45 62	6.0
29,	40 00	52 00	38 00	42 00	14 00	39 00	46.00	42 00	42 25	7.00	41.00	45 00	43 50	43 25	4.00
30,	40 00	50.00	34 00	39 50	16 00	36 25	45 50	38 00	39 43	9 25	38 50	44 50	40 50	41 00	6.0
31,	46 00	64 00	46 00	50 50	18 00	38.50	53 00	46 00	45 87	14 50	39.00	49 50	47 00	45 62	10.50
Sums,	1,306 00	1,618 00	1,304 00	1 378 00	389.00	1,302 00	1,526 50	1,469 00	1 393 81	248 75	1,331.50	1,477 00	1,407 05	1,562 26	165 25
Means,	42.13	52.16	42.06	44 45	12.55	42 00	49 24	47.39	44 96	8 02	42 95	47 64	45 39	48 46	5 33

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Soil Temperature Records for 1888. October.—CONTINUED.

DATE.	SIX INCHES.					TWELVE INCHES.					TWENTY-FOUR INCHES.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	47 00	50 50	54.00	51.37	7 00	51.50	51.25	53 00	52.18	2 75	55 00	54 75	54.00	54.44	1 00
2,	51 50	52 00	50 50	50 87	2 00	53.50	53.50	53 50	53.50	0.00	54.50	54 50	54 50	54 50	0.00
3,	45 00	46 50	46.00	45.87	1 50	51 50	50 50	50 50	50 70	1 00	54.50	54 50	54 00	54 25	0.50
4,	43 50	47 00	48 00	46 62	4 50	49 00	49 00	50.00	49 50	1 00	53 50	53 25	53.00	53.18	0 50
5,	45.50	49 00	51.50	49 37	6.00	50.00	49 50	51 00	50 37	1 50	52.50	52 50	53 00	52 75	0 50
6,	51.00	53 50	53.00	52 62	2 50	51 50	53 00	52 50	52 37	1 50	52 50	52 50	53.00	52 75	0 50
7,	48 50	50 50	50.25	49 87	2 00	52 00	51 75	52 00	51 93	0 25	52 00	53.50	53 50	53 12	1 50
8,	49 00	49.50	48.00	48 62	1 50	51.50	51.50	51.50	51 50	0.00	53 25	53.25	53 00	53 12	0 25
9,	43.50	44 50	44 50	44 25	1.00	49 50	49.00	49 00	49.12	0.50	53 00	52 50	52 00	52.37	1.00
10,	42.00	45 50	46.50	45 12	4 50	48.00	47 50	48 50	48 12	1.00	52 00	51 50	51.00	51 37	1 00
11,	42 00	43 50	44 00	43 37	2 00	48.00	47 50	47 50	47 62	0 50	51 50	51.00	51 00	51.12	0 50
12,	42 00	44 50	45 00	44.25	2.50	45.00	46 00	47 00	46 25	2.00	49.50	49.25	49 50	49.43	0 25
13,	44 00	46 00	46 00	45.00	2 00	47 00	47 00	47 50	47.25	0 50	49.50	49 50	49 50	49 50	0.00
14,	44.50	41.00	46.25	44.51	5 25	47 50	47 25	48 00	47 69	0.75	49 75	49 75	49 75	49 75	0 00
15,	42.50	46 00	46 50	45 62	4 00	47 50	47.00	48 00	47 62	1 00	49 75	49.75	49.75	49.75	0 00
16,	46 50	49 00	48 00	47.87	2.50	48 00	48.50	49.00	48 62	1.00	49 75	49.75	50.00	49 87	0 25
17,	46 50	47.75	47 00	47.08	1.25	48.50	48 50	48.75	48 62	0 25	50.50	50 00	50.00	50 00	0 00
18,	45 00	47 00	47 00	46 50	2 00	48 50	48 00	48 50	48 37	0.50	50 00	50.00	50 00	50 00	0 00
19,	45.00	46 50	48.00	46 87	3.00	47 50	48 00	48.50	47 87	1 00	50 00	50 00	49 75	49.87	0 25
20,	45 50	45 00	42 50	43 87	3.00	48 00	48 00	47.50	47 87	1 00	50 00	50 00	49 50	49 75	0 50
21,	41 00	41 25	41 00	41 08	0.25	46.00	45 50	45 50	45 62	0 50	49 50	49 25	49.00	49 18	0 50
22,	39 00	42.50	42.50	41 62	3.50	44 50	44.00	44 00	44 12	0.50	48 50	48 25	48 25	48 31	0.25
23,	43.25	45 00	46 75	45 43	3 50	45.50	45 50	46 25	45 87	0 75	48 00	48 00	48 00	48 00	0.00
24,	46 50	45 50	44 50	45 25	2.00	47.00	47 00	47 00	47.00	0.00	48.00	48 50	48.50	48 37	0.50
25,	41 50	46 00	46 00	44 87	4.50	46.00	45.75	47 00	46 43	1.25	48 50	48 50	48 50	48.50	0.00
26,	44 25	46 00	46.50	45.68	2.25	47 00	46.75	47 25	47.08	0 50	48 50	48 50	48 50	48 50	0 00
27,	46.00	47 50	46 50	47 62	2 50	47.50	47.50	49 00	45 25	1 50	48 50	48 50	48.50	48 50	0.00
28,	48.50	48.00	46 00	47 12	2 50	48.50	48 75	48 50	48.58	0 25	49 00	49.00	49 00	49 00	0 00
29,	43 50	45 00	45 00	44.62	1.50	47 50	47.00	47 00	47.12	0 50	49 25	49 00	49 00	49 06	0.25
30,	42 00	43 50	43 50	43.12	1 50	46 50	46 00	46 00	46.12	0 50	48.75	48.75	48 50	48.64	0.25
31,	41 00	45 50	47.00	45 12	6 00	45 50	45.50	46 50	46 00	1.00	48.25	48.25	48.00	48 13	0 25
Sums,	1,387 00	1,440 50	1,433 25	1,431 51	90 00	1 495 50	1,491 50	1,505,75	1,499 22	25.25	1,567 25	1,576 25	1,563 50	1,565.08	10.50
Means,	44.74	46 47	46 23	46.18	2 90	48.24	48.11	48 57	48.36	0 81	50.55	50.84	50.43	50 48	0 34

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Soil Temperature Records for 1888. November—Continued.

Date.	Six Inches.					Twelve Inches.					Twenty-four Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	44.25	58.50	49.75	50.56	14.25	46.75	46.75	48.00	47.37	1.75	48.00	48.25	48.25	48.18	0.25
2,	47.50	50.75	52.00	50.56	4.50	48.50	48.50	49.75	49.12	1.25	48.50	49.00	49.00	48.87	0.50
3,	52.00	52.00	49.00	50.50	3.00	50.50	51.00	51.00	50.87	0.50	49.50	49.75	50.00	49.81	0.50
4,	44.50	47.75	48.50	47.31	4.00	49.00	48.75	49.00	48.98	0.25	50.25	50.25	50.00	50.12	0.25
5,	46.00	59.25	50.00	51.31	13.25	48.75	48.50	49.50	49.06	1.00	49.75	49.75	49.75	49.75	0.00
6,	50.25	53.50	54.50	53.19	4.25	50.00	50.50	51.50	50.87	1.50	49.75	50.00	50.25	50.06	0.50
7,	50.50	50.00	48.00	49.12	2.50	52.00	51.25	50.75	51.19	1.25	50.50	51.00	51.00	50.87	0.50
8,	46.50	46.25	46.50	46.43	0.25	50.00	49.00	48.75	49.12	1.25	51.00	50.50	50.50	50.62	0.50
9,	48.50	52.00	54.00	52.12	5.50	49.50	49.50	51.50	50.50	1.00	50.25	50.25	50.25	50.25	0.00
10,	56.00	57.50	52.00	54.47	5.50	52.50	54.50	55.00	54.25	2.50	50.50	51.00	51.50	51.12	1.00
11,	46.50	45.00	48.00	44.87	3.50	51.50	50.00	48.75	49.75	2.75	52.00	51.75	51.25	51.56	0.75
12,	40.75	48.00	42.50	42.19	2.25	47.00	46.25	46.50	46.56	1.75	50.50	50.00	49.50	49.88	1.00
13,	39.50	42.75	42.50	41.81	3.25	45.25	44.75	45.50	45.25	0.75	49.00	48.75	48.25	48.56	0.75
14,	39.50	42.25	43.50	42.19	4.00	44.50	44.00	44.75	44.50	0.75	48.00	47.75	47.50	47.69	0.50
15,	42.50	45.75	47.00	45.56	4.50	44.50	46.50	46.00	45.75	2.00	45.50	46.00	46.50	46.12	1.00
16,	46.00	45.25	43.00	44.81	3.00	46.25	46.50	46.00	46.19	0.50	47.00	47.25	47.50	47.81	0.50
17,	39.50	38.50	38.00	38.50	1.50	44.50	43.75	43.00	43.56	1.50	47.50	47.25	47.00	47.19	0.50
18,	37.00	36.50	36.50	36.62	0.50	42.00	41.50	41.00	41.37	1.00	46.25	46.00	45.75	45.94	0.50
Sums,	817.25	866.50	840.25	841.12	79.50	863.00	861.50	866.25	864 21	23.25	883.75	883.50	883.75	880.60	9.50
Means,	45.40	48.14	46.73	47.28	4.41	47.94	47.86	48.12	48.01	1.29	49.09	49.08	49.09	48.91	.52

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Soil Temperature Records for 1888. November.

Date.	At Surface.					One Inch.					Three Inches.				
	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.	7 A. M.	2 P. M.	9 P. M.	Mean.	Range.
1,	46.00	71.00	54.00	56.25	25.00	41.50	68.00	50.25	52.50	26.50	42.50	58.50	50.25	49.12	11.00
2,	48.00	70.00	62.00	60.50	22.00	46.00	68.50	55.50	56.37	22.50	46.25	64.75	54.00	55.75	18.50
3,	56.00	57.00	38.00	47 25	19:00	54.50	53.25	43.25	48.56	11.25	53.50	53.09	46.00	49.62	9.50
4,	41.00	60.00	57.00	50.75	19.00	39.00	53.00	47.00	46.50	14.00	41.00	50.75	47.50	46.68	9.75
5,	50.00	66.00	56.00	57.00	16.00	44.50	66.25	51.00	53.18	21.75	44.50	57.75	50.25	50.68	13.25
6,	54.00	70.00	56.00	59.00	16.00	51.50	62.00	56.00	56.37	10.50	49.75	53.00	55.00	54.44	8.25
7,	42.00	54.00	42.00	45.00	12.00	45.50	51.00	45.00	46.62	6.00	48.00	50.75	47.00	48.19	3.75
8,	44.00	48.00	46.00	44.75	3.00	43.25	44.50	45.75	44.81	2.50	44.50	45.00	45.75	45.25	1.25
9,	54.00	65.00	60.00	59.75	11.00	51.00	59.50	57.50	56.37	8.50	49.50	56.00	56.00	54.37	6.50
10,	65.00	51.00	41.00	51.00	21.00	61.00	58.00	44.50	52.00	16.50	59.00	58.50	48.00	53.37	11.00
11,	38.00	42.00	33.00	36.50	9.00	39.50	40.50	36.00	38.00	4.50	42.50	42.25	39.00	40.69	3.50
12,	34.00	50.00	36.00	39.50	16 00	34.50	45.25	37.00	38.44	10.75	37.00	44.00	40.00	40.25	7.00
13,	34.00	56.00	34.00	39.50	22.00	34.00	48.00	39.00	40.00	14.00	36.50	45.50	40.50	40.75	9.00
14,	34.00	56.00	47.00	46.00	22.00	34.00	48.00	48.00	42.00	14.00	36.50	45.00	48.00	41.87	8.50
15,	40.00	45.00	44.00	43.25	5.00	42.50	48.75	45.50	45.56	6.25	42.50	47.50	46.50	45.75	5.00
16,	46.00	48.00	30.00	37.25	16.00	47.75	48.75	36.00	40.87	11.75	46.75	44.50	39.50	42.56	7.25
17,	28.00	34.00	26.00	28.50	8.00	33.00	34.00	32.00	32.75	2.00	36.00	35.50	36.00	35.87	0.50
18,	28.00	34.00	32.00	31.50	6.00	33.00	32.50	33.00	32.62	1.00	36.00	36.00	36.00	36.00	0.00
Sums,	782.00	967.00	797.00	833.25	268.00	775.00	924.75	797.25	828.52	204.25	792.25	888.25	830.25	831.21	138.50
Means,	43.44	53.72	44.28	46.29	14.89	43.06	51.37	44.29	45.75	11.34	44.01	49.34	46.37	46.18	7.97

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